INSTRUCTIONS

JSM-5200
SCANNING MICROSCOPE

No. ISM5200-1AE
(MP152001)

JEOL

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No. ISM5200-1AE
(MP152001)

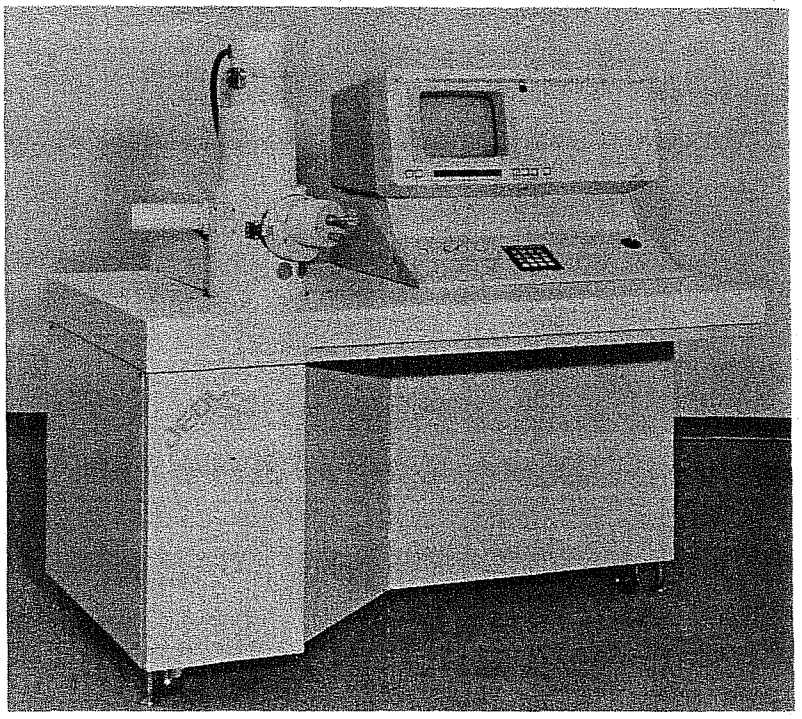
JEOL LTD. / JEOL TECHNICS LTD.

Tokyo Japan

8810001KP

PREFACE

Although the instrument is easy to operate, you are requested to read this instructions carefully before starting its operation, for better understanding of the keypoints of operation and for full comprehension of operational techniques.



Description of this instruction manual may be slightly different from the factual microscope due to its subsequent modification.

CAUTION: The export from Japan of the product introduced in this brochure requires the export permit by the Japanese government, according to the Foreign Exchange and Trade Control Law.

PRECAUTIONS

1. Observe the specified requirements for installation of installing the microscope.
2. Do not forget to ground the microscope when installing it.
3. When the work is done on the microscope console table, take care that:
   (a) Nothing enters the console table.
   (b) Nothing such as water is spilled on the table.
4. Even when the microscope is not used for a long period of time, evacuate the column of microscope regularly to keep vacuum.
5. Be sure to turn off power always before connecting the Camera for Scanning Image cable.
6. Take care not to damage or let dust stick on O-rings and their mating surfaces when handling the parts with O-rings.
7. Do not put the microscope in the VENT condition for a long time (within several hours).

CONTENTS

PREFACE 0-1
PRECAUTIONS 0-2
(CONTENTS) 0-3

1. GENERAL DESCRIPTION, SPECIFICATIONS AND LAYOUT 1-1
1.1 General Description 1-2
1.2 Specifications 1-2
1.3 Installation Requirements 1-5

2. MICROSCOPE DESCRIPTION 2-1
2.1 Names of Main Components 2-2
2.2 Specimen Stage 2-4
2.3 Control Panel 2-5
2.4 Display Panel 2-8
2.5 Rear Panel 2-10

3. OPERATION 3-1
3.1 Outline of Operating Procedure 3-2
3.2 Startup 3-3
3.3 Specimen Mounting and Exchange/Specimen Movement 3-5
3.3.1 Specimen Mounting and Exchange 3-5
3.3.2 Specimen Mounting and Specimen Movement Ranges 3-7
3.4 Observation 3-13
3.4.1 Operation for Quick Imaging 3-13
3.4.2 Focusing and Astigmatism Correction with Automatic Functions 3-17
3.4.3 Manual Operation 3-18
3.4.4 Astigmatism Correction 3-22
3.4.5 Flat Panel Key Operation 3-23

3.4.6 Liquid Crystal Display (LCD) 3-34
3.4.7 Checkers 3-36
3.5 Photography 3-38
3.5.1 Ordinary Photography 3-38
3.5.2 Multi Exposure Photography 3-40
3.6 Shutdown 3-42
3.7 Restart 3-43
3.8 Electron Gun Filament Replacement 3-44
3.9 Electron Gun Alignment 3-48
3.10 Specimen Preparation 3-53
3.11 Troubles in Operation 3-55
3.12 How to Obtain High Quality Images and Photographs 3-57

4. PRACTICAL USE OF SCANNING MICROSCOPE 4-1
4.1 General Description of Scanning Electron Microscope 4-3
4.1.1 Comparison of Microscopes 4-3
4.1.2 Principle of Scanning Electron Microscope 4-4
4.1.3 Signals Obtained from Specimens 4-5
4.1.4 Composition of Scanning Microscope 4-7
4.1.5 Component Functions of Scanning Microscope 4-9
4.2 Selection of Accelerating Voltage (ACCELERATING VOLTAGE) 4-11
4.3 Effects of Electron Probe Diameter (SPOT SIZE) 4-13
4.4 Focusing and Astigmatism Correction (FOCUS • STIGMATOR) 4-14
4.4.1 How to Use Focusing Device (COARSE • FINE) 4-14
4.4.2 How to Use STIGMATOR (X • Y) 4-14
4.4.3 How to Use Automatic Focusing Device (AFD) and Automatic Astigmatism Correctin Device (ASD) 4-15
4.5 Scanning System 4-16
4.5.1 Scanning Mode 4-16
4.5.2 Scanning Speed 4-16
4.5.3 TV Scanning 4-16

4.5.4 Automatic Magnification Corrector (MAC) 4-17
4.5.5 Viewing Field Fine Shift (IMAGE SHIFT) 4-18
4.6 Specimen Stage 4-19
4.7 Detector 4-21
4.8 Display System 4-22
4.8.1 Rapid Exposure Marker 4-22
4.8.2 Automatic Contrast & Brightness Control (ACB) 4-24
4.9 Camera for Scanning Image (CSI) 4-25
4.9.1 Camera for Scanning Image and Film 4-25
4.9.2 Types and Specifications of Cameras for Scanning Images 4-26
4.9.3 Component Parts of Camera for Scanning Image 4-27
4.9.4 Aperture Value Setup 4-32
4.9.5 Preparation of Camera for Scanning Image 4-33
4.10 Auto Data Recording 4-34
4.10.1 Film Number 4-35
4.10.2 Data Readout on Photograph 4-36
4.11 Photographing Time and Photo Time Monitor 4-37
4.12 Recording CRT (PRD1/UHR) 4-38
4.13 Evacuation System 4-39
4.13.1 Operation of Evacuation System 4-39
4.13.2 Evacuation Sequence Indication 4-40

ABBREVIATIONS USED IN THIS MANUAL

AC	:	Alternating Current
ACB	:	Automatic Contrast & Brightness Control
AFD	:	Automatic Focusing Device
ASD	:	Automatic Astigmatism Correction Device
CPU	:	Microprocessor
CRT	:	Cathode-Ray Tube
DP	:	Oil Diffusion Pump
LED	:	Light Emitting Diode
MAC	:	Automatic Magnification Corrector
PMT	:	Photomultiplier Tube
RP	:	Oil Rotary Pump
TV	:	Television Mode (Image)
WD	:	Working Distance

* Abbreviations or word(s) squared as [ ] in this manual indicate those scribed on the control panel of this microscope, unless otherwise specified.

This microscope is subject to modifications for improvement of its performance. Consequently, there will be some difference between your scanning microscope and that explained in this manual.

CHAPTER 1 GENERAL DESCRIPTION, SPECIFICATIONS AND INSTALLATION REQUIREMENTS

CONTENTS

1.1 General Description 1-2

1.2 Specifications 1-2

1.3 Installation Requirements 1-5

CHAPTER 1 GENERAL DESCRIPTION, SPECIFICATIONS AND INSTALLATION REQUIREMENTS

1.1 General Description

This microscope provides a series of automatic operations from evacuation to photography, and stably maintains high image quality and high performance for a long time of period.
Especially, the main functions for its operations are concentrated on a single keypad, and many memory functions are provided for astigmatism correction, image quality (brightness and contrast) adjustment, magnification setting, etc. Operation parameters are indicated on a single liquid crystal display (LCD) to facilitate operator convenience greatly.
The JSM-5200 can be widely used ... as a training and experimental equipment at universities and high schools, as an inspection and analysis instrument for quality control at factories, or for research and development in the hightech fields such as biotechnology, new materials and semiconductors.

1.2 Specifications

(1) Performance

Resolution	:	5.5 nm (SEI; 25 kV, WD = 10 mm)
Magnification	:	15 × (WD = 48 mm) to 200,000 × (25 steps) Digital indication on LCD (Liquid Crystal Display) Automatic Magnification Corrector (MAC) built-in at WD = 10, 20, 48 mm Magnification memory built-in
Image modes	:	Secondary electron image (SEI) Backscattered electron image (BEI)

(2) Electron optical system (EOS)

Accelerating voltage	:	1, 2, 5, 10, 15, 20, 25 kV (7 steps) Linked with objective lens hysteresis eliminating function Digital indication on LCD
Electron gun filament	:	Precentered W hairpin filament cartridge type (electron gun; hinged cap type)
Filament monitor	:	Built-in
Automatic gun bias	:	Built-in for high accelerating voltage (5 to 25 kV) and low accelerating voltage (1 to 2 kV) (2 steps)
Alignment	:	Mechanical
Lens system	:	Three-stage; two condenser lens (CL) and one objective lens (OL)
OL aperture	:	Fixed type
Focusing	:	Manual and Automatic Focusing Device (AFD)
Stigmator	:	8-pole electromagnetic type Manual and Automatic Astigmatism Correction Device (ASD) Stigmator memory built-in

Viewing field fine shift : Electromagnetic type ±10μm in all directions (at 25 kV, WD = 20 mm; JOYSTICK)

Probe current range : 10^{-12} to 10^{-9} A

Probe current detector : Digital Microammeter (DMA; option)

(3) Specimen stage

Specimen stage type : Eucentric

Specimen movements :
X direction ..... 10 mm
Y direction ..... 20 mm
Tilt ..... -40° to +90°
Rotation ..... 360° (endless)
Working distance (WD) .. 10, 20, 48 mm
Digital indication on LCD

Specimen size :
10 mm dia. × 10 mmh
32 mm dia. × 10 mmh (option)
51 mm dia. × 10 mmh (option)
2" dia. IC wafer (option)

Specimen exchange : Draw-out type (specimen stage; hinged door type)

(4) Detectors and displays

SE/BE detector : Scintillator and photomultiplier tube Backscattered Electron Detector (BEIS), Transmitted Electron Detector (TED), Cathodoluminescence Detector (CLD), Infrared Cathodoluminescence Detector (CLDIR) and Energy Dispersive X-ray Spectrometer (EDS) are optionally available.

Scanning mode : Frame scan/Line scan/TV scan

Scanning speed :
Observation 0.27, 0.36, 3, 10 sec/frame, TV scan
Photographing 36, 90 sec/frame (50 Hz)
30, 75 sec/frame (60 Hz)

Magnification display: 15× to 200,000× (digital indication on LCD) Digital display on observation CRT; at 0.36 sec/frame scan

Observation CRT : One, 9" green CRT (for both observation and photography)

Display area : 135 × 180 mm (Max.)

Image quality control: Rapid-exposure system (also used as exposure meter)
Automatic Contrast and Brightness Control (ACB)

Operation condition display:

Upper line on LCD : Accelerating voltage, working distance, magnification, film number, photo speed

Lower line on LCD : Evacuation sequence, check data, warning, photo monitor

TV output terminal	:	BNC-R connector (75Ω)
TV output signal	:	EIA or CCIR, composite, positive polarity, 1 Vp-p, H = 15.75 kHz, V = 60 Hz (EIA)/ V = 50 Hz (CCIR)
Monitor TV	:	TV monitor (TVM9, TVM20; option): only EIA

(5) Scanning image photographing device

Camera (option)	:	Manual and automatic shutters built-in
CSI1	:	For 6 × 7 roll film (photo/CRT mag. ratio: 0.5)
CSI2	:	For instant pack film (0.75)
CSI3	:	For 35 mm roll film (0.25)
CSI5	:	For instant 4 × 5 film (1.0)
CSI6	:	For Polaroid autofilm (0.85)
Exposure meter	:	Rapid-exposure system (indicated on CRT image)
Photo monitor	:	Digital indication on LCD
Data recording	:	Data display; ON/OFF changeover possible (on the observation CRT and photograph) Image on character base; ON/OFF changeover possible. Accelerating voltage, magnification, micron marker, micron value, film number 6 digits = 4 digits (manual) + 2 digits (auto/manual)
Recording CRT	:	One, 9" short-persistence CRT (PRD1; option) Ultrahigh Resolution CRT (UHR; option)

(6) Vacuum system

Vacuum control	:	Fully automatic control (Evacuation sequence indication on LCD)
Ultimate pressure	:	7×10^{-4} Pa (5×10^{-6} Torr) or better
Vacuum pumps	:	
Oil rotary pump	:	One, 100 ℓ/min.
Oil diffusion pump	:	One, 420 ℓ/sec. (with water cooling baffle)
Evacuation time	:	Approx. 3 min.

(7) Checkers and Safety devices

Checkers		
Auto checker	:	5 warning indication on LCD
Manual checker	:	9 items indication on LCD (including 3 items for optional devices)
Safety devices	:	Protective devices built-in for prevention of power and water failures and vacuum pressure increase.

(8) Others

Service outlet	:	One, built-in (AC100V, 2A for optional devices)
Casters	:	Provided for instrument movement
Cabinet	:	Keeps specimen stubs, tools, instruction manual, etc.

1.3 Installation Requirements

(1) Power supply and cooling water

Power supply	:	Single-phase, AC100V, 50/60 Hz (voltage fluctuation ±10% or less) 2.0 kVA (normally power consumption 1.2 kVA)

(Note: Another power line is required when the total power consumption of options is over 0.8 kVA.)

Grounding terminal	:	One, 100Ω or less
Cooling water		
Faucet	:	One, 10 mm (O.D.)
Drain	:	One, 25 mm or more (I.D.)
Flow rate	:	2 ℓ/min.
Pressure	:	0.08 to 0.25 MPa
Temperature	:	20±5°C (Water temperature at the outlet: 35°C or less)

(2) Environment

Temperature	:	20±5°C
Humidity	:	60% or less
Floor vibration	:	2μm or less at 5 Hz (in X/Y/Z directions)
Stray magnetic field	:	0.3μT or less
Floor size	:	2,000 × 2,200 mm or more
Entrance	:	800(W) × 1,800(H) mm or more

(3) External appearance

Dimensions	:	1,250(W) × 750(D) × 1,230(H) mm
Weight	:	317 kg (basic instrument)

(4) Installation layout

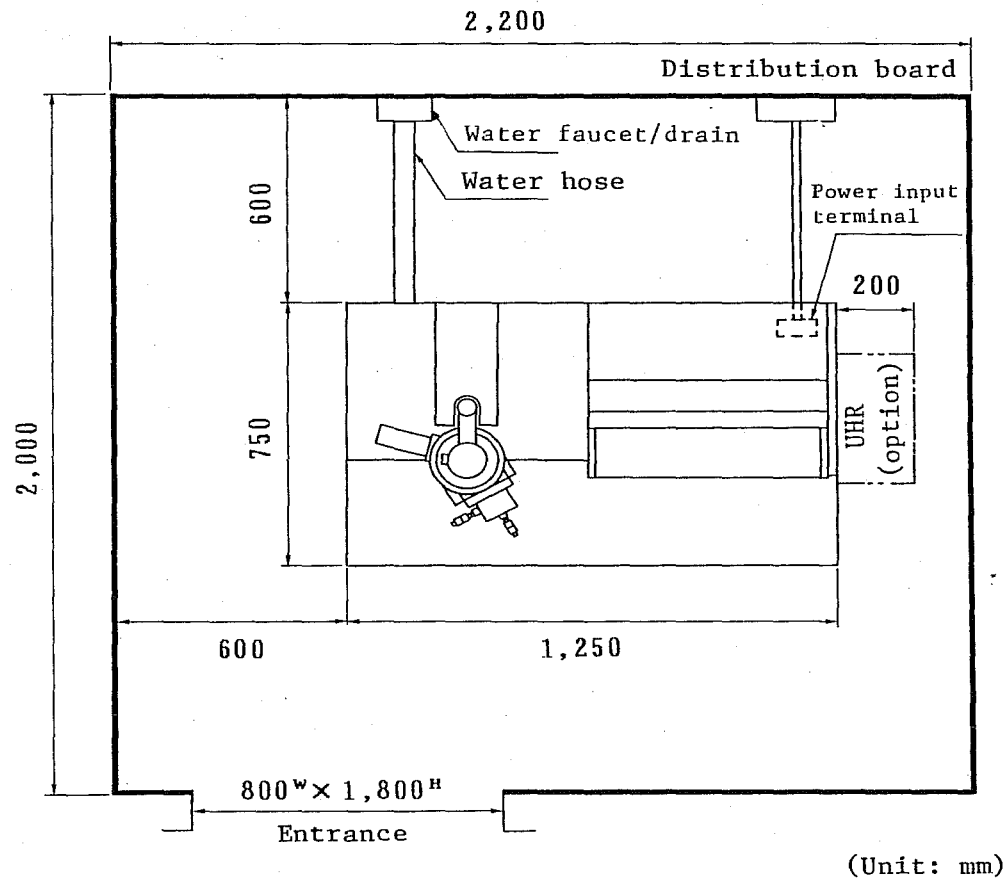


Fig. 1-1 Installation Layout

Notes:
1. Fig. 1-1 shows a typical installation layout. Be sure to maintain a service area on the left side and the rear even if only a small layout space is available.
2. Install the microscope well apart from facilities producing vibrations or electromagnetic waves (such as roads, busy passages, railroads, elevators, air conditioners and their outlets, transmission lines, etc.)
3. This microscope does not necessarily require any blackout curtain.

CHAPTER 2 MICROSCOPE DESCRIPTION

CONTENTS

2.1 Names of Main Components 2-2

2.2 Specimen Stage 2-4

2.3 Control Panel 2-5

2.4 Display Panel 2-8

2.5 Rear Panel 2-10

CHAPTER 2 MICROSCOPE DESCRIPTION

2.1 Names of Main Components

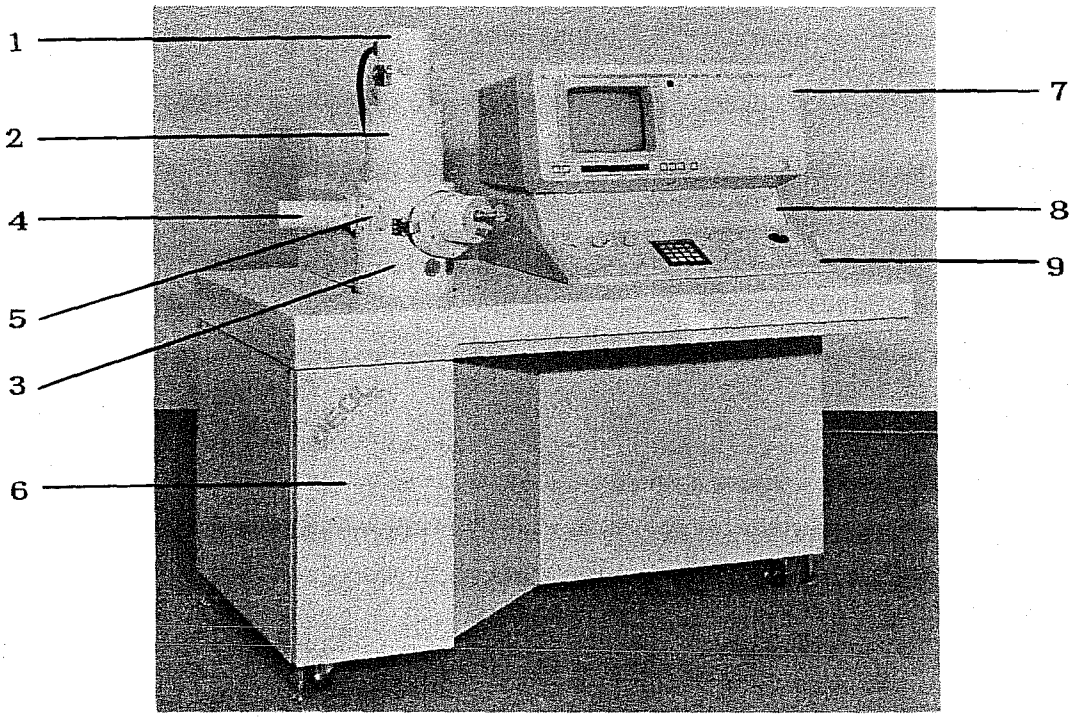


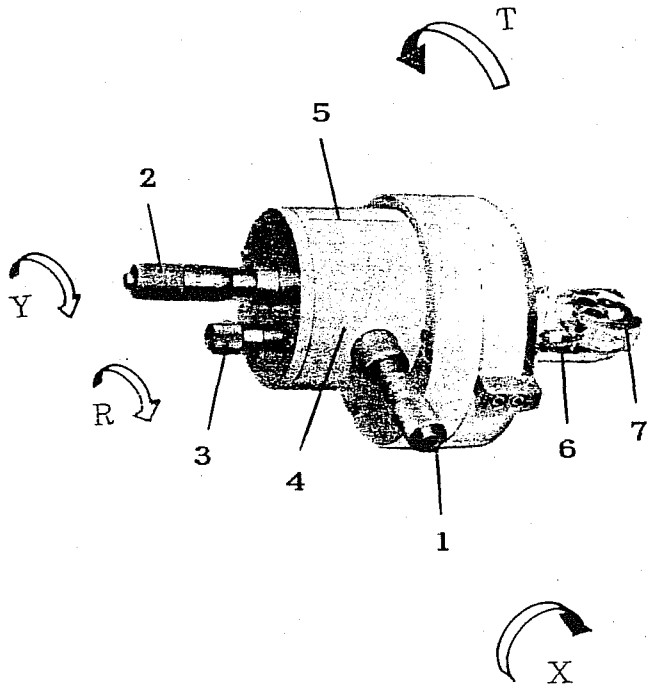
Fig. 2-1 Main Components

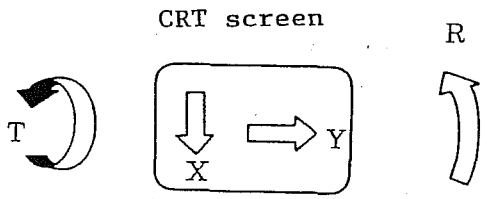
1	Electron gun	:	Filament is attached.
2	Column	:	Electron optical system (include anode, condenser lens, objective lens and deflector coil, etc.)
3	Specimen chamber /Specimen stage	:	Specimen mounting·movement (with X, Y, R and T controls)
4	Detector	:	Detects secondary electrons and backscattered electrons.

5 Attachment installation port:
2 ports are provided for the following optional detectors.
. Energy dispersive X-ray spectrometer (EDS)
. Backscattered electron detector (BEIS)
. Cathodoluminescence detector (CLD)
. Infrared cathodoluminescence detector (CLDIR), etc.

6	Cabinet	:	Keeps specimen mounts, tools, instruction manual, etc.
7	Display panel	:	Displays the viewing image, photographing image and operation conditions.
8	Attachment housing	:	Houses optional devices.
9	Control panel	:	Controls and switches are provided.

2.2 Specimen Stage





When both the X and Y controls read 5 mm, the electron beam is incident on the center of the specimen stub. (at WD = 20 mm)

Fig. 2-2 Specimen Stage and Image Movement

1	X control	:	Moves the specimen in right/left directions as seen from the specimen stage front (within an inclined plane at the time of tilt.)
2	Y control	:	Moves the specimen in front/rear directions as seen from the specimen stage front.
3	R control	:	Rotates the specimen.
4	T control	:	Tilts the specimen when the whole specimen stage is tilted.
5	Tilt angle indicator	:	Adjusts to the scale of specimen stage mounting flange.
6	Specimen movement section	:	Working distance (WD) 10 mm and 20/48 mm (However, common 20 mm and 48 mm specimen movement section, for 48 mm, turn the specimen stage mounting flange upside down. For 10 mm, exchange the specimen holder with the specimen movement section only for its use.)
7	Specimen holder	:	Slide system exchange of specimen holders (for WD = 20 mm and 48 mm). For WD = 10 mm, special holder is provided.

2.3 Control Panel

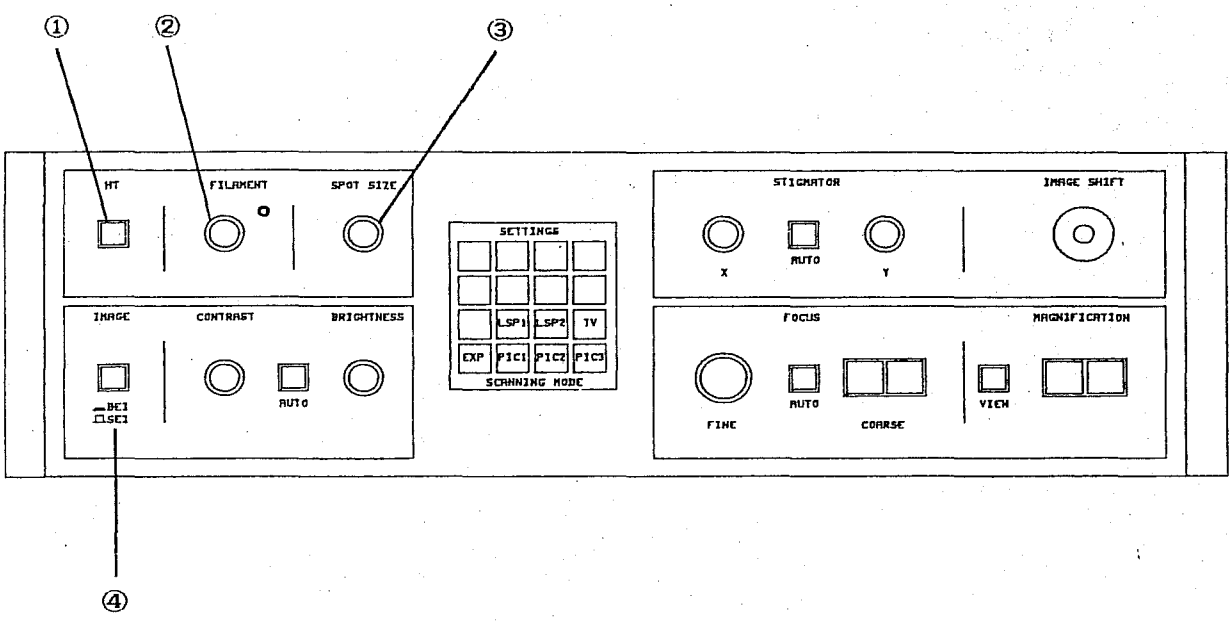


Fig. 2-3a Control Panel

1	HT	:	Accelerating voltage ON/OFF switch (LED lights at ON: RED)
2	FILAMENT	:	Electron gun filament heating current control knob (with stopper)
	Filament monitor lamp	:	The lamp lights if FILAMENT control is set at a position beyond 11 o'clock. If it does not light, the filament is burnt out. (Lamp lights: YELLOW)
3	SPOT SIZE	:	Electron probe diameter and intensity control knob
4	IMAGE SEI/BEI	:	Detector mode selector
	SEI	:	Secondary electron image
	BEI	:	Backscattered electron image (LED lights at ON: GREEN)

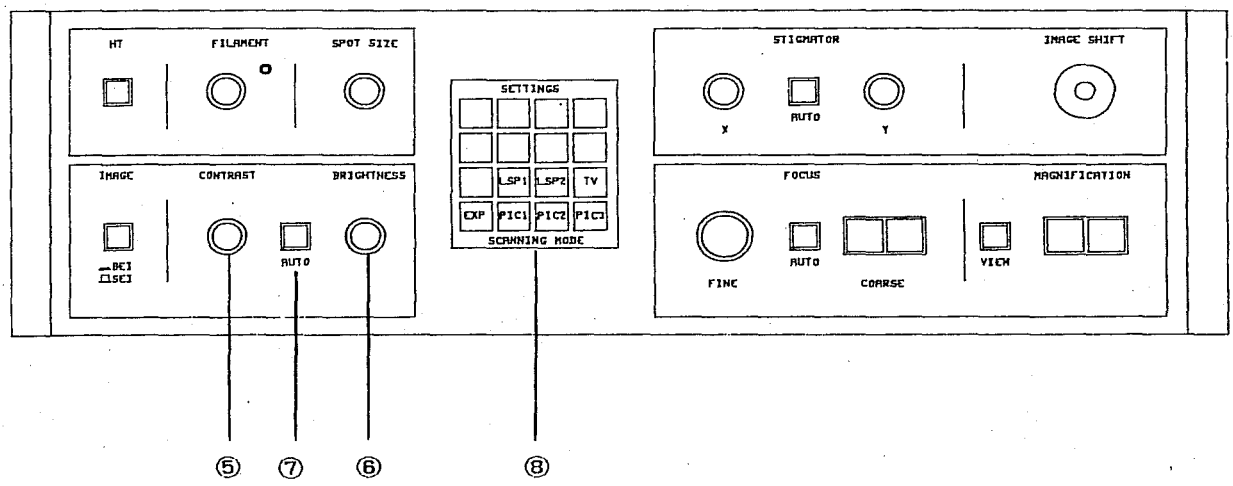


Fig. 2-3b Control Panel

5 CONTRAST : Contrast control knob

6 BRIGHTNESS : Brightness control knob

7 AUTO : Automatic Contrast and Brightness Control (ACB) start switch.
(LED lights at ON: YELLOW)

8 Flat panel key (Keypad)

SETTINGS : Accelerating voltage/working distance/memory functions/film data setting

SCANNING MODE : Scanning mode/speed setting

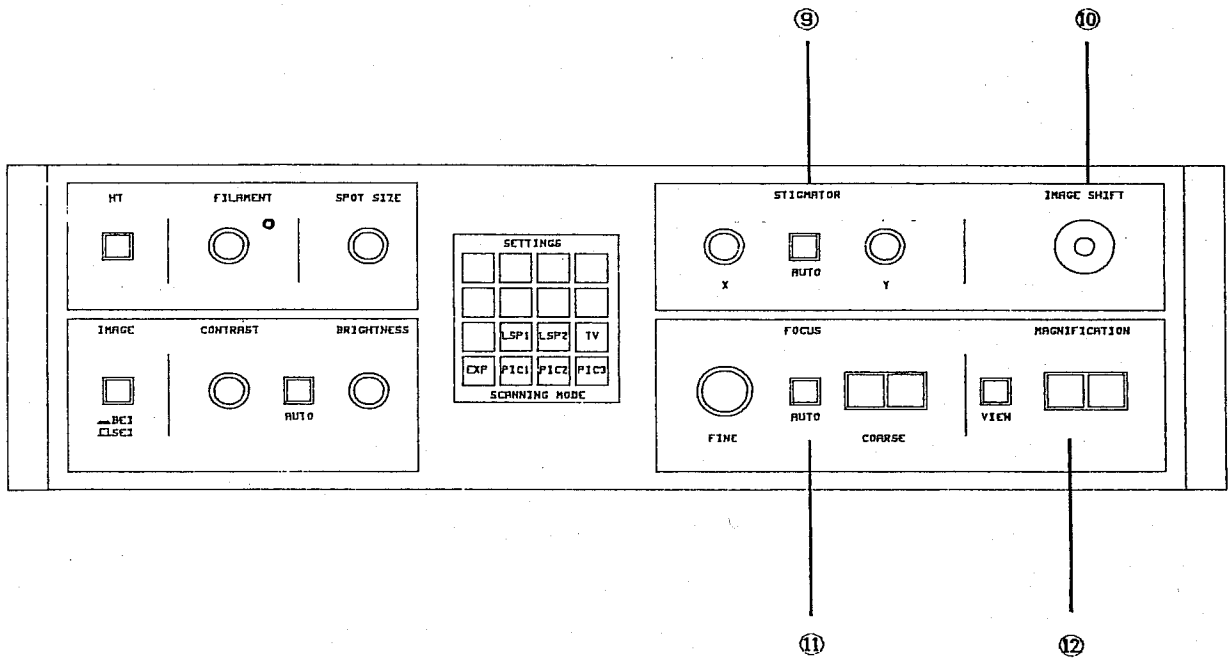


Fig. 2-3c Control Panel

9	STIGMATOR	:	Astigmatism correction knob (X·Y)
	AUTO	:	Automatic astigmatism correction device (ASD) start switch (LED lights at ON: YELLOW)
10	IMAGE SHIFT	:	Electromagnetic image fine shift with joystick
11	FOCUS	:	Focusing
	FINE	:	Focus fine control
	COARSE	:	Focus coarse switch (Left: Down, Right: Up) Buzzes at MIN/MAX.
	AUTO	:	Automatic Focusing Device (AFD) start switch (LED Lights at ON: YELLOW)
12	MAGNIFICATION	:	Magnification selection switch (Left: Down, Right: Up)
	VIEW	:	Preset magnification ON/OFF switch (LED Lights at ON: YELLOW)

2.4 Display Panel

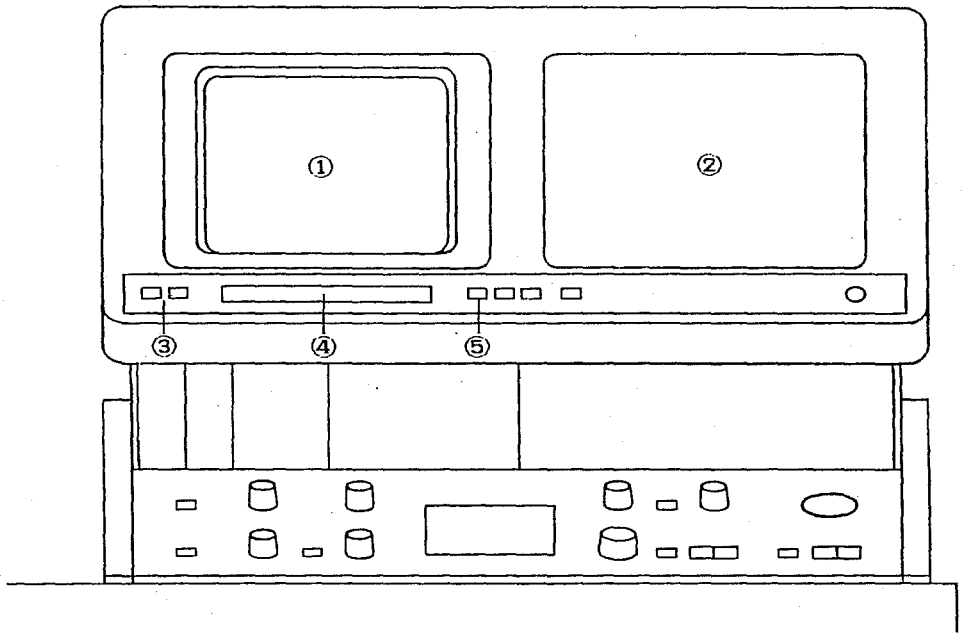


Fig. 2-4a Display Panel

1	Observation CRT	:	9" green CRT for both observation and photography of scanning image
2	Photographing CRT installation space	:	9" short-persistence CRT (PRD1: option) is installed.
3	VACUUM	:	Evacuation operation switch
	VENT	:	Column and specimen chamber reach atmospheric pressure (admit air). (LED lights at VENT: GREEN)
	EVAC	:	Evacuates the column and specimen chamber to vacuum. (LED lights at EVAC: YELLOW)
4	Operation condition display	:	Liquid crystal display (LCD) (A 40 columns × 2 lines; with a back light)
	Upper line	:	Accelerating voltage, working distance, magnification, film number, photographing speed and others are displayed.
	Lower line	:	Evacuation sequence, check data, warning and others are displayed. (This changes into a photo monitor during photography.)
5	CHECK SELECT	:	Check item selection switch

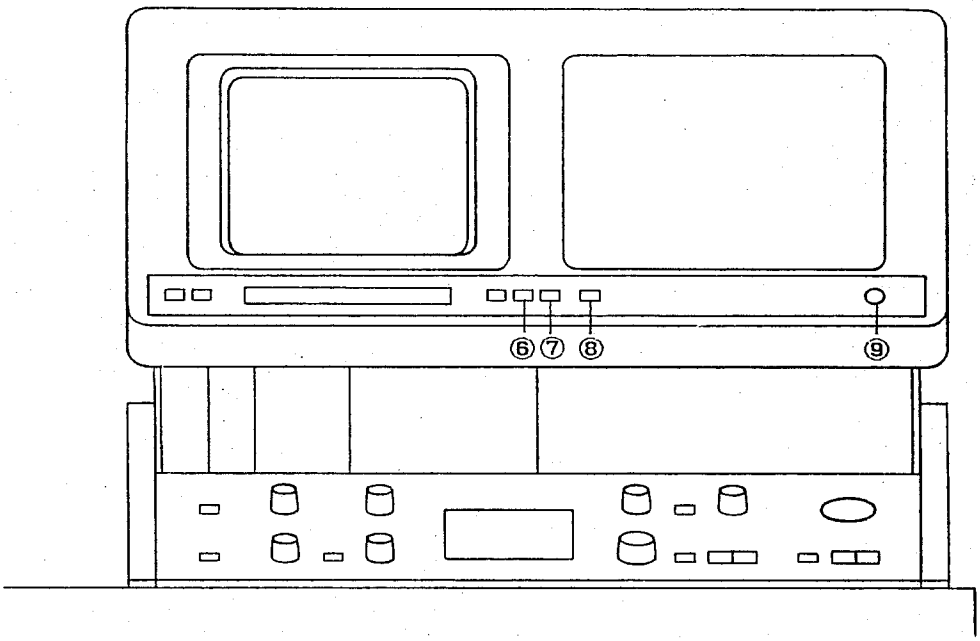


Fig. 2-4b Display Panel

6 [COUNT] : Film number counter ON/OFF switch
(At ON, 2 digits at the right of film number automatically count at each photographing.)

7 [PHOTO SPEED] : Photographing speed selection switch

> : For normal photographing: 90 sec (50 Hz)/75 sec (60 Hz)

>> : For quick photographing: 36 sec (50 Hz)/30 sec (60 Hz)

Mark (> or >>) is displayed at the right edge of upper line in LCD.

8 [SHUTTER] : Automatic shutter
(LED lights at ON: GREEN)
The remaining photographing times are displayed at the right edge of lower line in LCD.

9 [POWER] : Power key switch

Start up: [OFF] → [START] → [ON]

Shut down: [ON] → [OFF]

2.5 Rear Panel

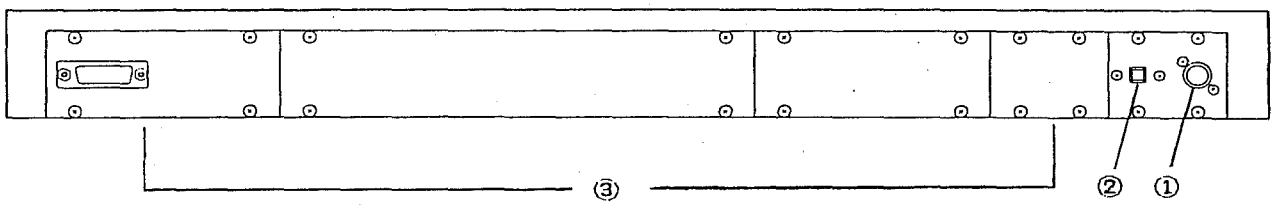


Fig. 2-5 Rear Panel

1 TV signal output terminal (BNC-R connector)
2 CPU reset switch
3 Connector port for several attachments

CHAPTER 3 OPERATION

CONTENTS

3.1 Outline of Operating Procedure 3-2

3.2 Startup 3-3

3.3 Specimen Mounting and Exchange/Specimen Movement 3-5

3.3.1 Specimen Mounting and Exchange 3-5

3.3.2 Specimen Mounting and Specimen Movement Ranges 3-7

3.4 Observation 3-13

3.4.1 Operation for Quick Imaging 3-13

3.4.2 Focusing and Astigmatism Correction with Automatic Functions 3-17

3.4.3 Manual Operation 3-18

3.4.4 Astigmatism Correction 3-22

3.4.5 Flat Panel Key Operation 3-23

3.4.6 Liquid Crystal Display (LCD) 3-34

3.4.7 Checkers 3-36

3.5 Photography 3-38

3.5.1 Ordinary Photography 3-38

3.5.2 Multi Exposure Photography 3-40

3.6 Shutdown 3-42

3.7 Restart 3-43

3.8 Electron Gun Filament Replacement 3-44

3.9 Electron Gun Alignment 3-48

3.10 Specimen Preparation 3-53

3.11 Troubles in Operation 3-55

3.12 How to Obtain High Quality Images and Photographs 3-57

CHAPTER 3 OPERATION

3.1 Outline of Operating Procedure

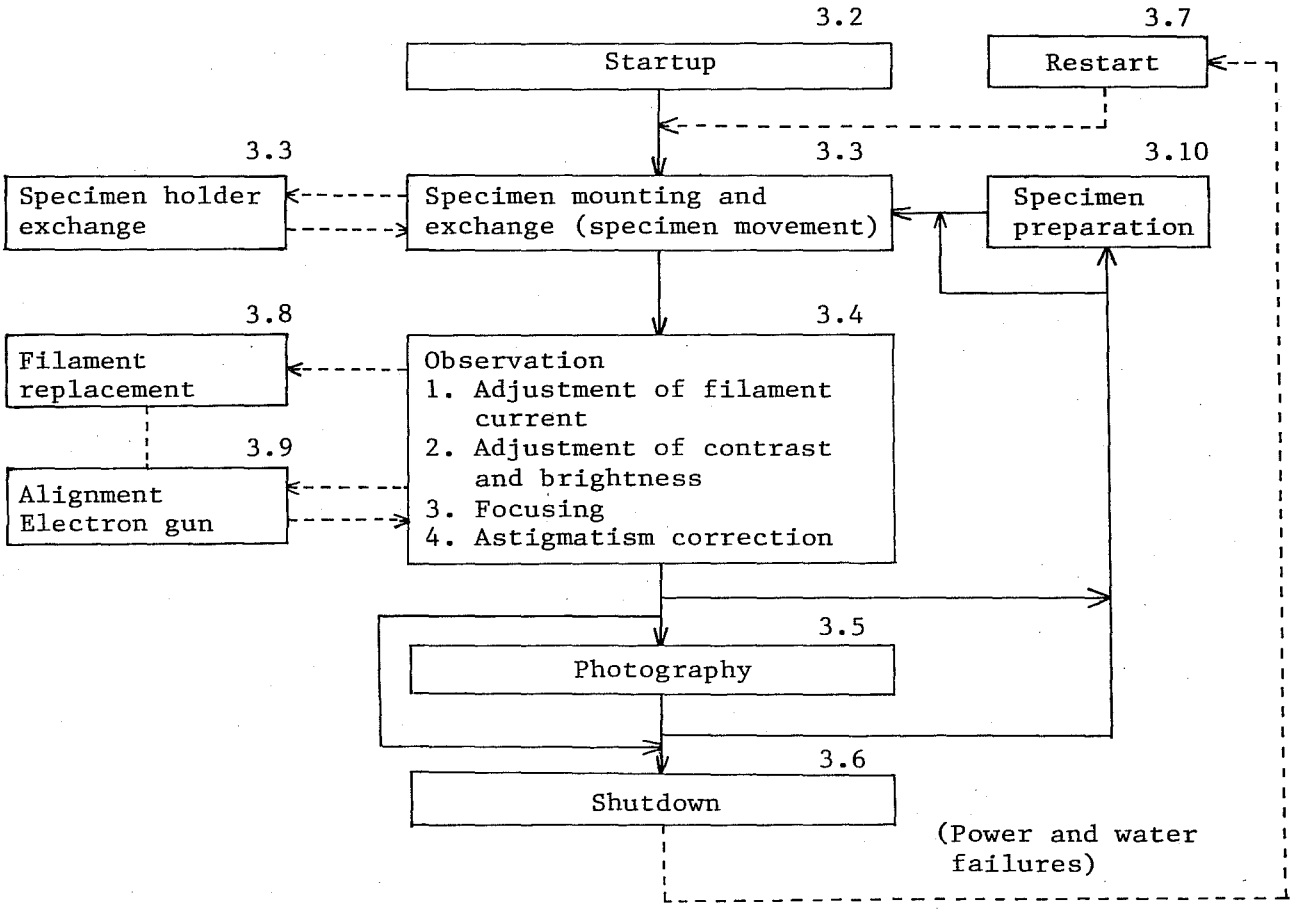


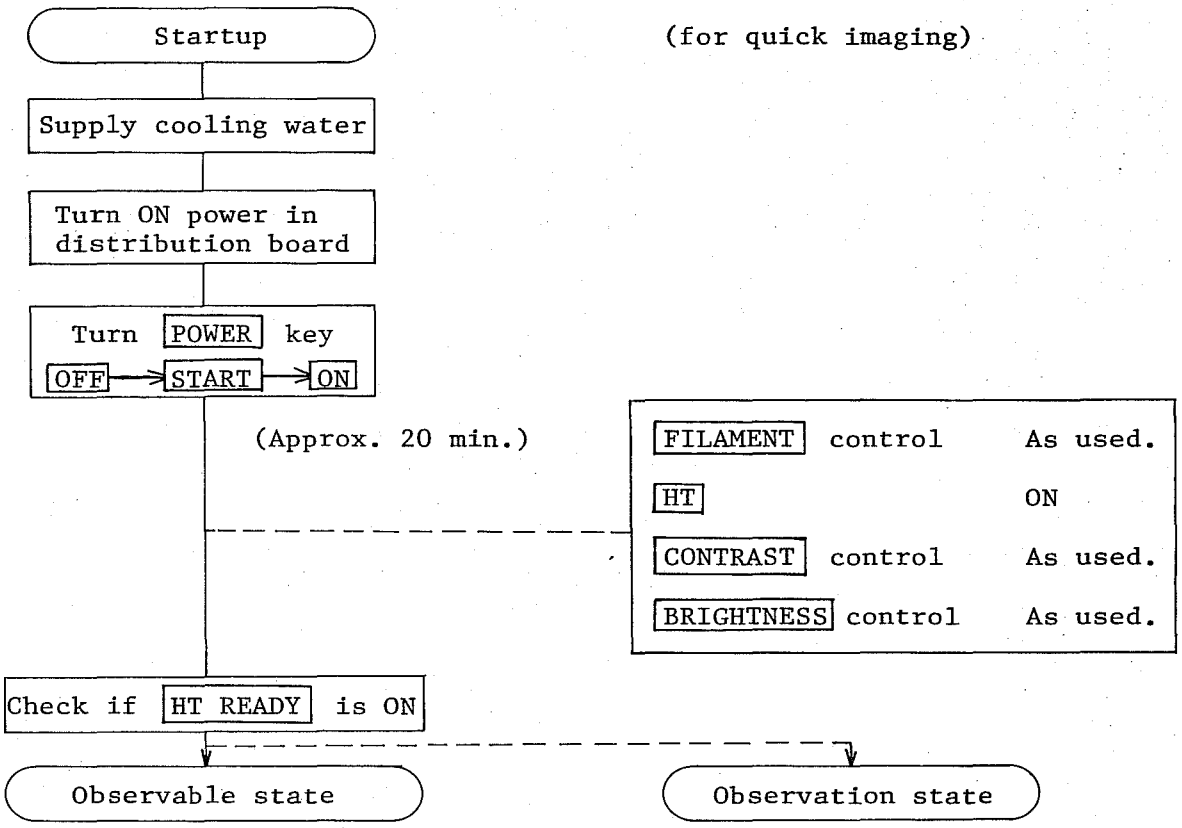
Fig. 3-1 Operating Procedure

——— routine operation

----- as required

Notes: 1. When mounting the Camera for Scanning Image (CSI), be sure to install it prior to startup.
2. When mounting the attachments (especially for mounting and exchanging the specimen), refer to the respective instruction manuals for them.

3.2 Startup



1. Turn on the tap to supply cooling water. Set the flow rate to around 1.5 to 2 ℓ/min.
   Note: The flow rate exceeding 2 ℓ/min may cause excessive cooling of the oil diffusion pump (DP) or vibration.
2. Turn ON the distribution board switch and insert the key into the POWER switch located at the right-hand bottom of the display panel. Turn the key fully to the START and release it (returns to ON .) The DP WAIT sequence indicator on Liquid Crystal Display (LCD) lights up and the oil rotary pump starts to rotate.
3. The microscope is automatically evacuated and the HT READY sequence indicator on LCD light up in approx. 20 min to make observation possible.

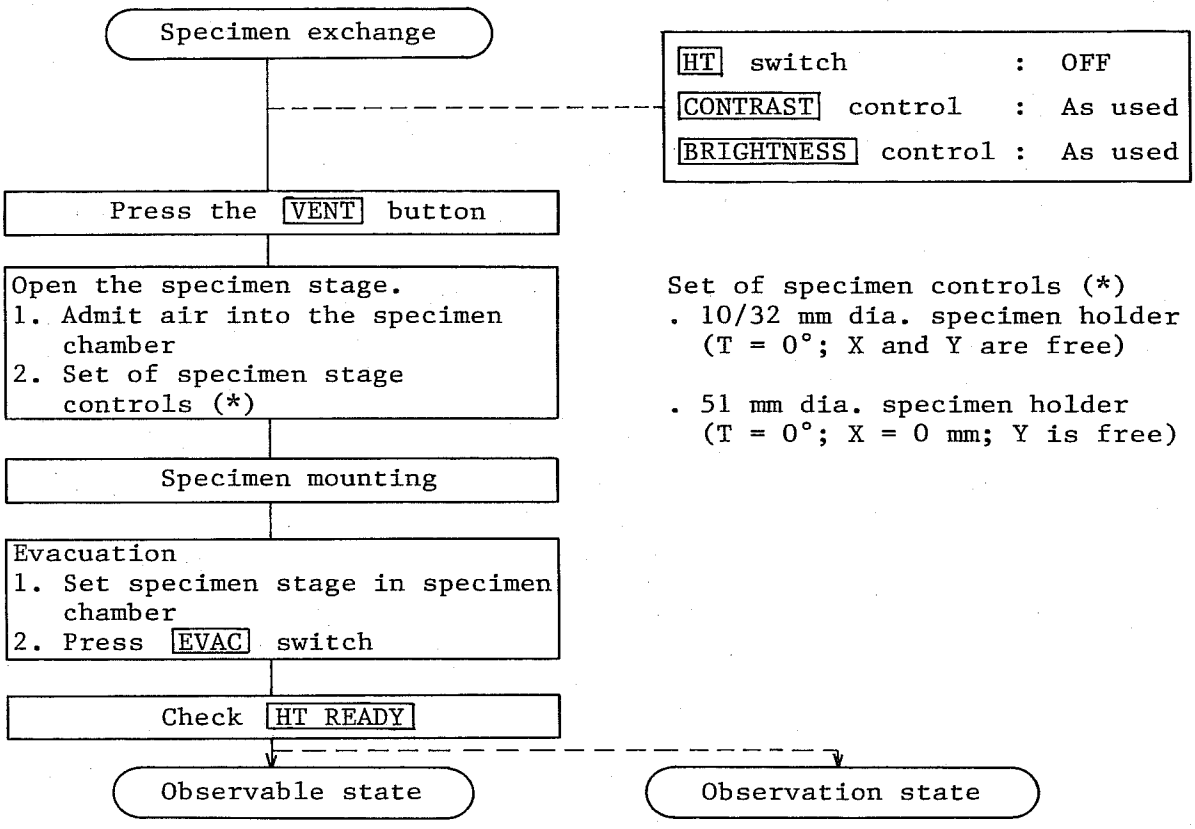
4. Initial settings of switches and controls

[IMAGE] [SEI/BEI] switch	:	[SEI] (LED goes out.)
[HT] switch	:	ON (Red LED lights up.)
[FILAMENT] control	:	As used
[SPOT SIZE] control	:	10 to 12 o'clock position
[CONTRAST] control	:	As used
[BRIGHTNESS] control	:	As used

5. Push SCANNING MODE [TV] or [PIC1] and press AFD and ACB [AUTO] start switches in that order after completion of their respective operations (after image appears.)

3.3 Specimen Mounting and Exchange/Specimen Movement

3.3.1 Specimen Mounting and Exchange


Specimen exchange
HT switch : OFF
CONTRAST control : As used
BRIGHTNESS control : As used
Press the VENT button
Open the specimen stage.
1. Admit air into the specimen chamber
2. Set of specimen stage controls (*)
Set of specimen controls (*)
. 10/32 mm dia. specimen holder (T = 0°; X and Y are free)
. 51 mm dia. specimen holder (T = 0°; X = 0 mm; Y is free)
Specimen mounting
Evacuation
1. Set specimen stage in specimen chamber
2. Press EVAC switch
Check HT READY
Observable state
Observation state

1. Press the VENT button
2. When the specimen chamber reaches atmospheric pressure in approx. 40 sec, set T = 0°, then open the specimen stage.
3. Choose suitable specimen holders (refer to Fig. 3-3).
4. Fix the specimen to the specimen holders with fixing screws after the observation surface has been adjusted at the top of the specimen holder.
   - 10 mm dia. specimen holder ..... Specimen holder rim top
   - 32 mm dia. and 51 mm dia. specimen holders (option) ..... Specimen holder rim top
   - IC wafer holder (option) ..... No adjustable type

Notes: 1. In using optional specimen holders, refer to their instruction manuals.
2. The magnification is corrected when the specimen observation surface is aligned with the specimen holder rim top. If it is not aligned, an error in magnification may develop and the observation surface will not be eucentric when the specimen is tilted.
3. 32 mm dia. and 51 mm dia. specimen holder can not be used at the 10 mm working distance (WD) in normal setting.

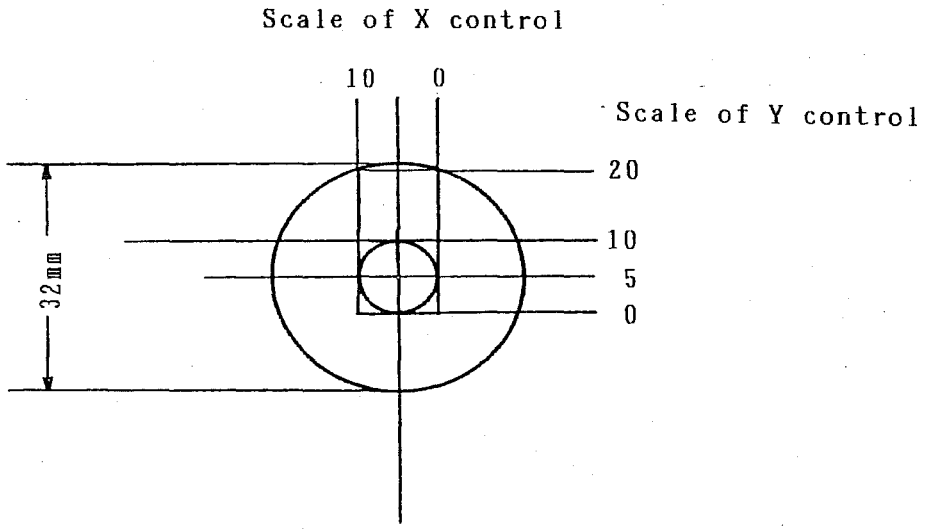


Fig. 3-2 Specimen Position

5. Set the specimen stage in the specimen chamber and evacuate the chamber by pressing the vacuum control button [EVAC].
6. In approx. 3 min, the [HT READY] sequence is indicated on LCD. Then, the microscope is ready for observation of images.
Note: When porous or gassy specimens are mounted, evacuation may take more time.

3.3.2 Specimen Mounting and Specimen Movement Ranges

1. Mounting

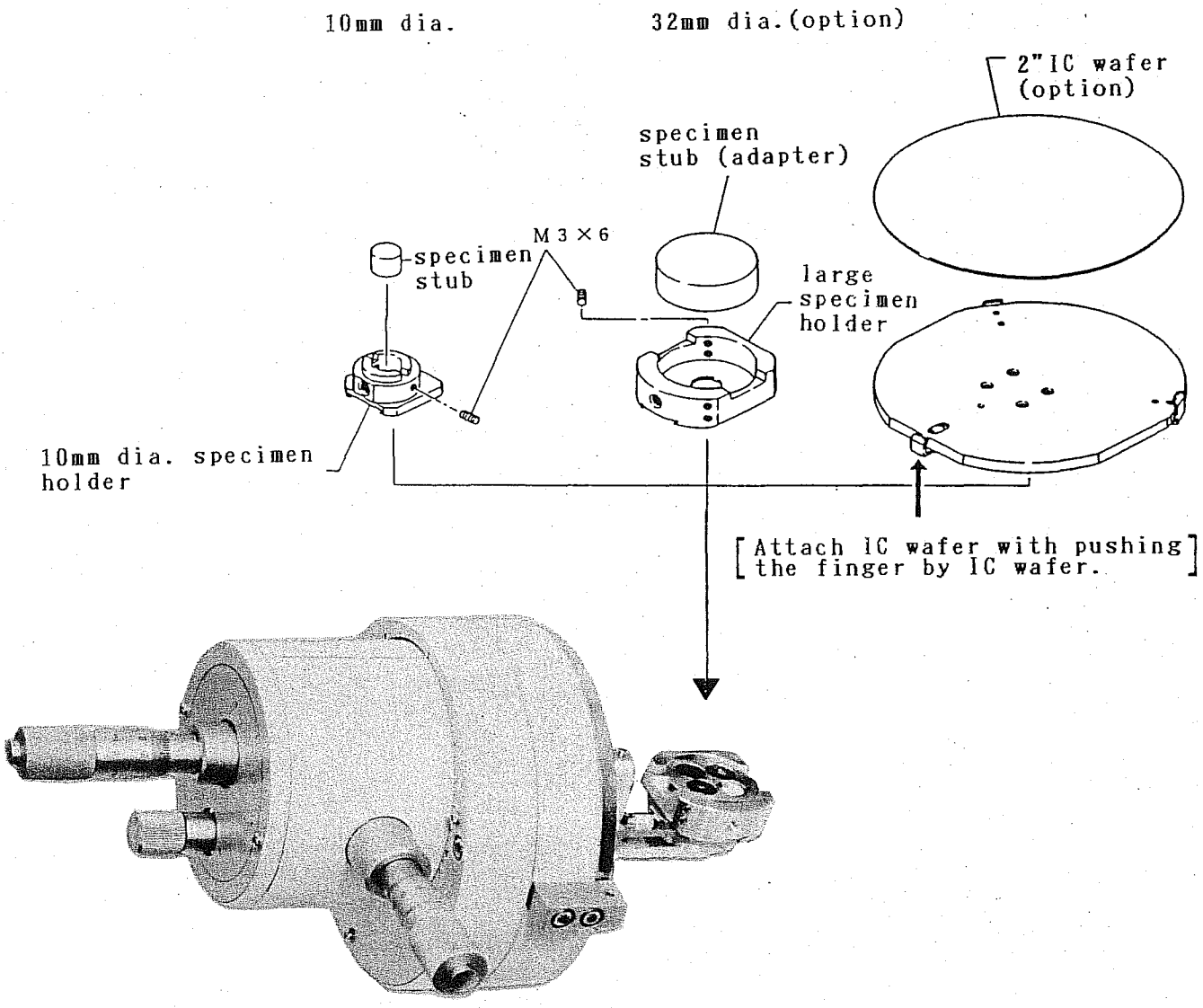


Fig. 3-3 Specimen Mounting

2. Specimen Movement Relation

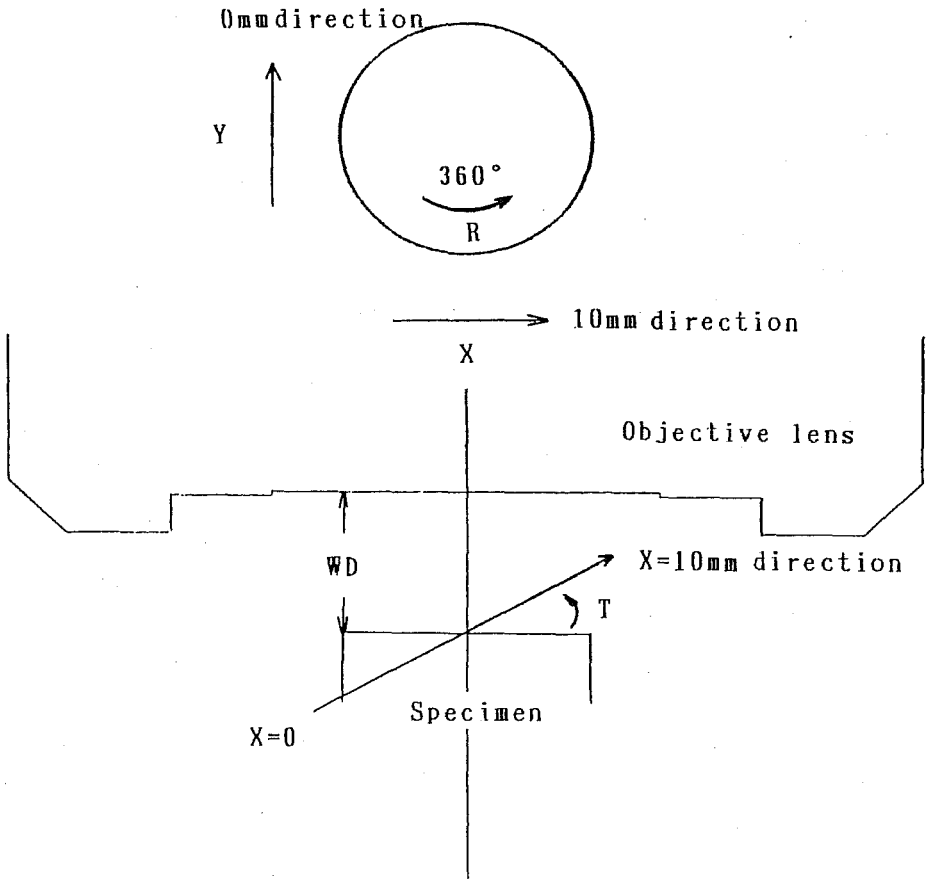


Fig. 3-4 Relation between Specimen Movement Direction and It's Tilt (as viewed from the front of specimen stage)

In eucentric type, the specimen moves toward X inside the tilted frame. Accordingly, note carefully that X movement corresponds to Z movement direction at 90° tilt.
When the X control reading is 0 mm, observation point is on the right-side of the specimen (as viewed from the specimen top).

3. Specimen Movement Range

(1) Specimen movement range in 10 mm dia. specimen (I)
(The relation between working distance and specimen position is shown.)

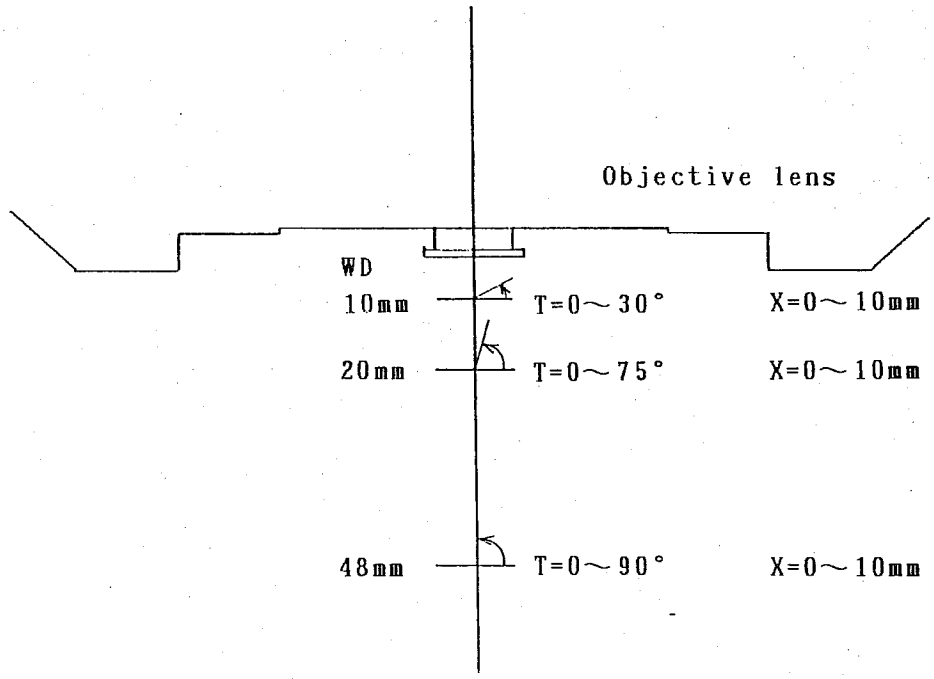


Fig. 3-5 Specimen Movement Range (I)

10 mm dia. specimen: Y movement 0 to 10 mm
(observable range 0 to 10 mm)

R movement 360° (Specimen holder for WD 10 mm has not R movement.)

WD mm	10	20	48
T(°)	0~30	0~75	0~90
X(mm) 0			
10			

■ shows specimen observable range.

Table 3-1 Specimen Movement Range (I)

Mount and move the specimen within the above specimen movement range.

Note: Because the observation surface will not be eucentric at working distance (WD) 10 mm, whole area (10 mm dia.) can not be fully observed with X movement when the specimen is tilted.

(2) Specimen movement range in 32 mm dia. specimen (II)
(The relation between working distance and specimen position is shown.)

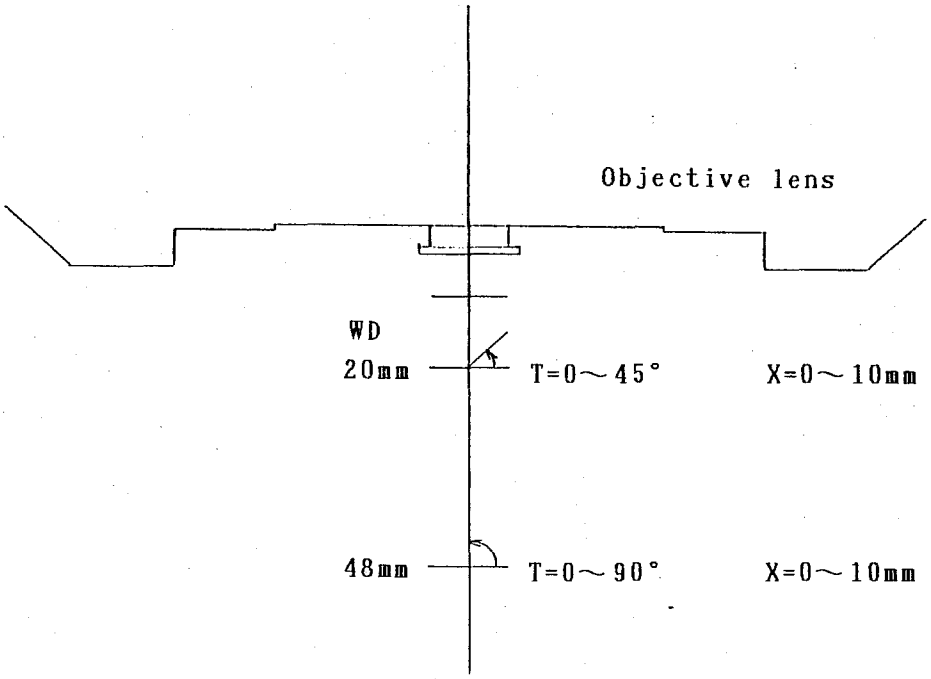
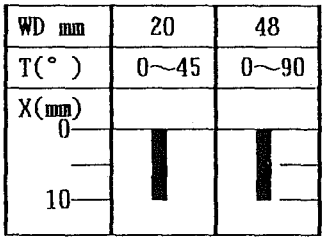


Fig. 3-6 Specimen Movement Range (II)

32 mm dia. specimen: Y movement 0 to 20 mm
(observable range 0 to 20 mm)

R movement 360°



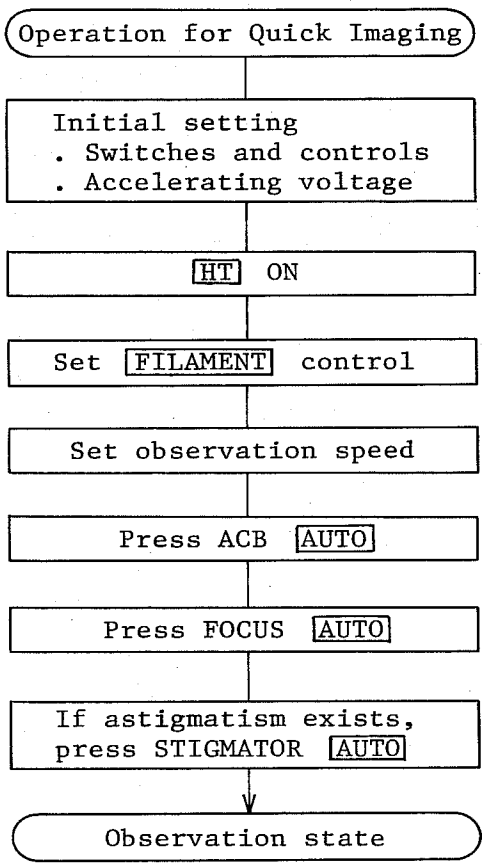
■ shows specimen observable range.

Table 3-2 Specimen Movement Range (II)

Mount and move the specimen within the above specimen movement range.

3.4 Observation

3.4.1 Operation for Quick Imaging



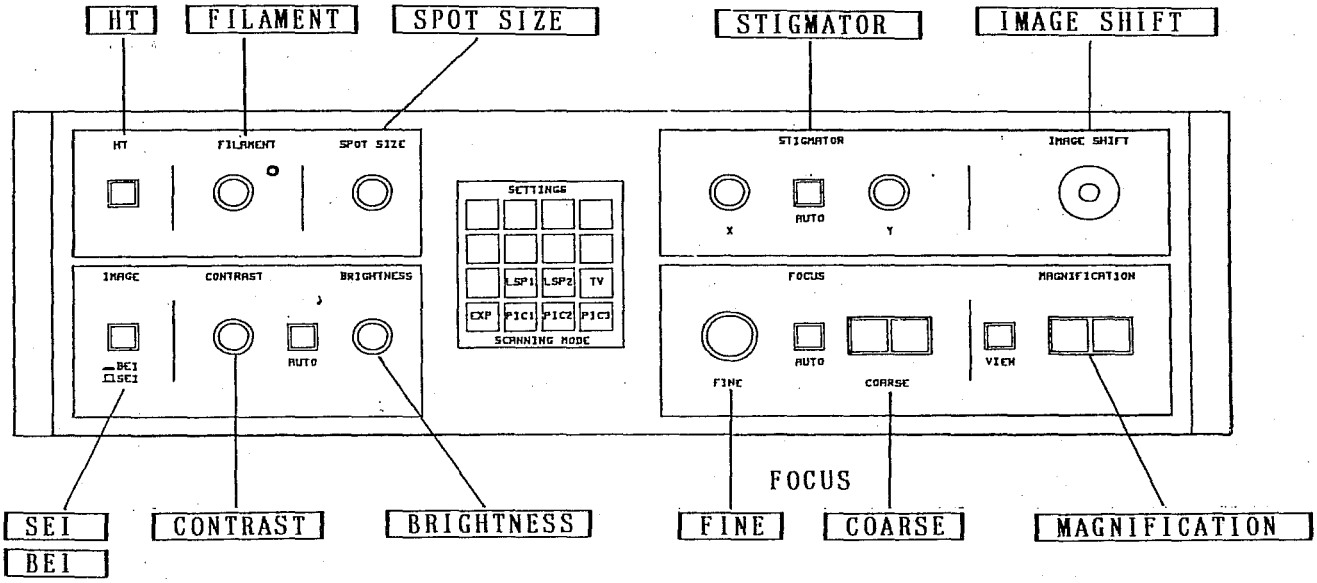


Fig. 3-7 Control Panel

1. Initial settings of switches and controls
   When the settings of some controls are made as follows, images are easily obtained. (Other controls may be set optionally.)

[IMAGE] [SEI/BEI] switch	:	Observation with secondary electron image [SEI] (LED goes out.) Observation with backscattered electron image [BEI] (Green LED lights up.)
[HT] switch	:	OFF (LED goes out.)
[SPOT SIZE] control	:	SEI; 10 to 12 o'clock position BEI; 12 to 3 o'clock position
[BRIGHTNESS] control	:	11 o'clock position
[CONTRAST] control	:	Around the center position

2. Setting of accelerating voltage
   Set voltage to the desired value by pressing SETTINGS [ACCV△] / [ACCV▽] switches.
   Accelerating voltages : 1, 2, 5, 10, 15, 20, 25 kV (7 steps)
3. When the Image Selector (IMS: option) or Multi Image Display (MID: option) is installed, select the [SEI] to obtain secondary electron image. (Change to the desired image later.)

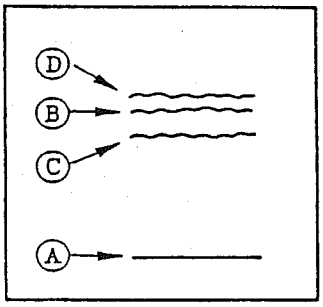


Fig. 3-8 LSP1 Mode

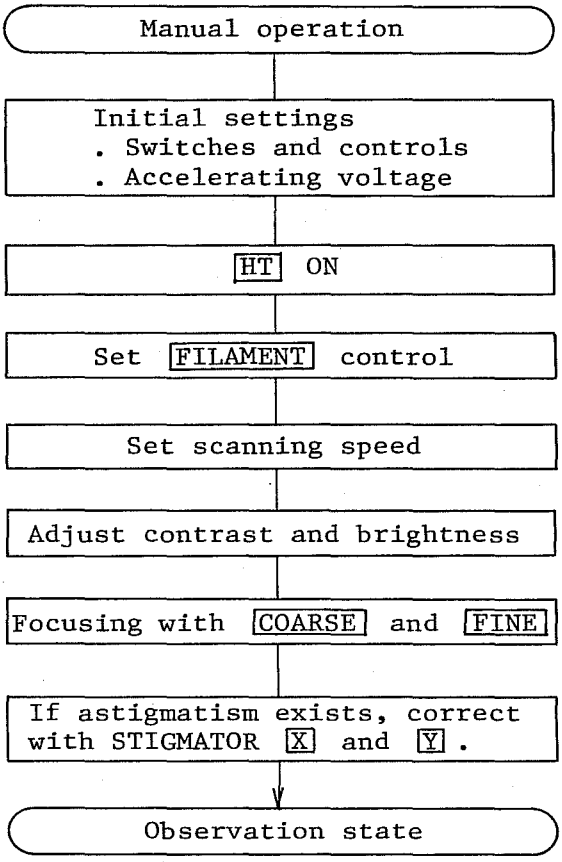
4. Press the [HT] switch to ON.
5. Turn the [CONTRAST] control to near the center of the range of rotation or select PMT with the [CHECK SELECT] switch and set the value to 400 ∿ 700.
6. Set the [FILAMENT] control to the observation position.
   Set the observation position immediately before the filament current saturation point (the second peak of the waveform obtained by the [LSP1]) as follows.
   1 Press the SCANNING MODE [LSP1] switch.
   2 Set the magnification to approx. 10,000× with the [MAGNIFICATION] switches.
   3 Turn the [FILAMENT] control clockwise. (The filament monitor lamp lights up at approx. 11 o'clock position.)
   4 Turn the [FILAMENT] control further in the clockwise direction to set the waveform to the second peak. (Refer to Fig. 3-8)
   Notes: 1. If the filament monitor lamp does not light up after the [FILAMENT] control has been turned beyond the 11 o'clock position, the filament has been burnt out and must be replaced with a new one.
   2. The waveform usually rises as A → B → C → D. In the case of new filaments, however, the first peak sometimes gets higher than the second as A → D → C → B.
   3. If the control is turned beyond the 3 o'clock position, the filament may be overheated and burnt out.
   5 Turn back the [FILAMENT] control slightly so that the waveform comes immediately prior to the second peak.

7. Set magnification to the desired value with the [MAGNIFICATION] switches.
8. Press the ACB [AUTO] start switch.
9. Press the SCANNING MODE [TV]. Then, press the FOCUS [AUTO] start switch.
   Note: When the AFD is used, if the specimen has low contrast or images are blurred due to noises, the AFD may not work properly. In this case, the amount of signals such as contrast should be increased and press the FOCUS [AUTO] start switch again.
10. No astigmatism correction is needed in ordinary operation with stigmator memory. But, if astigmatism is observed, press the STIGMATOR [AUTO] start switch.

3.4.2 Focusing and Astigmatism Correction with Automatic Functions

1. How to use the Automatic Focusing Device (AFD)
   (1) Press the FOCUS [AUTO] start switch once.
       Note: If in the use of the AFD the specimen has low contrast or images are blurred due to noise, the AFD may not work properly.
       In this case, the amount of signals such as contrast should be increased.
2. How to use the Automatic Astigmatism Correction Device (ASD)
   (1) Before starting the ASD, adjust the focus.
   (2) Press the STIGMATOR [AUTO] start switch once.
       Note: If in the use of the ASD the specimen has low contrast or images are blurred due to noise, the ASD may not work properly.
       In this case, the amount of signals such as contrast should be increased or use the ACB.

3.4.3 Manual Operation



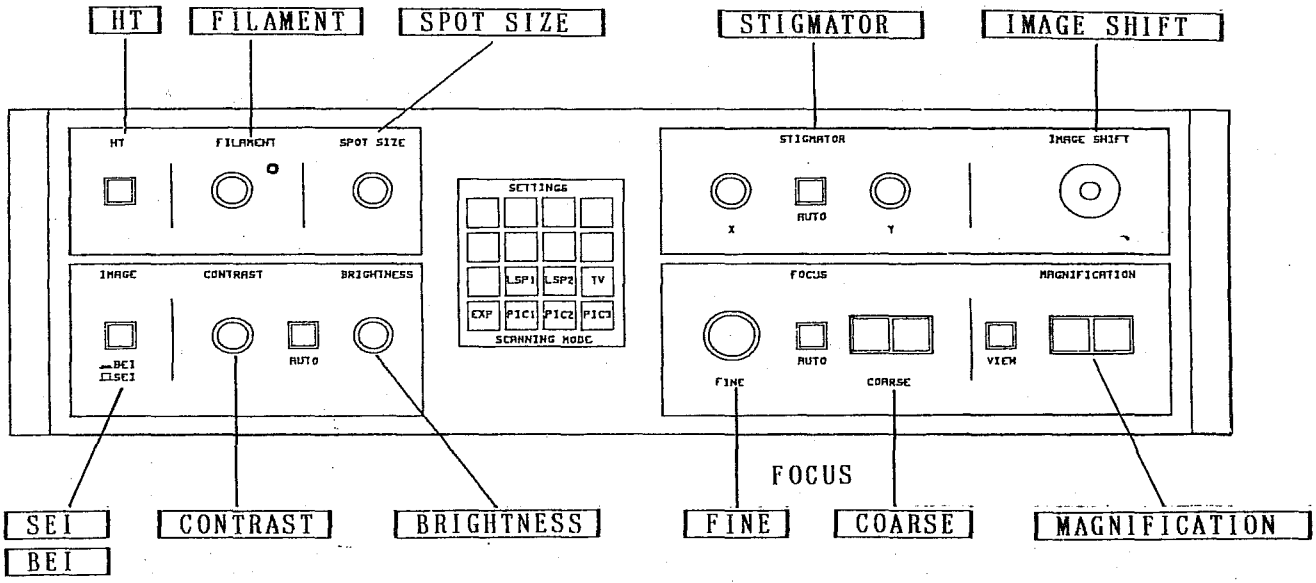


Fig. 3-9 Control Panel

1. Initial settings of switches and controls
   When the settings of some controls are made as follows, images are easily obtained. (Other controls may be set optionally.)

IMAGE SEI/BEI switch	:	Observation with secondary electron image SEI (LED goes out.) Observation with backscattered electron image BEI (Green LED lights up.)
HT switch	:	OFF (LED goes out.)
SPOT SIZE control	:	SEI; 10 to 12 o'clock position BEI; 12 to 3 o'clock position
BRIGHTNESS control	:	11 o'clock position
CONTRAST control	:	Around the center position

2. Setting of accelerating voltage
   Set voltage to the desired value by pressing SETTINGS ACCV△ / ACCV▽ switches.
   Accelerating voltages : 1, 2, 5, 10, 15, 20, 25 kV (7 steps)
3. When the Image Selector (IMS: option) or Multi Image Display (MID: option) is installed, select the SEI to obtain secondary electron image. (Change to the desired image later.)

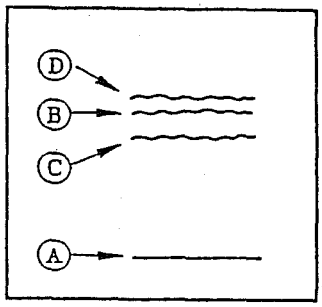


Fig. 3-10 LSP1 Mode

4. Press the [HT] switch to ON.
5. Turn the [CONTRAST] control to near the center of the range of rotation or select PMT with the [CHECK SELECT] switch and set the value to 400 ∿ 700.
6. Set the [FILAMENT] control to the observation position.
   Set the observation position immediately before the filament current saturation point (the second peak of the waveform obtained by the [LSP1]) as follows.
   (1) Press the SCANNING MODE [LSP1] switch.
   (2) Set the magnification to approx. 10,000× with the [MAGNIFICATION] switches.
   (3) Turn the [FILAMENT] control clockwise. (The filament monitor lamp lights up at approx. 11 o'clock position.)
   (4) Turn the [FILAMENT] control further in the clockwise direction to set the waveform to the second peak. (Refer to Fig. 3-10)
   Notes: 1. If the filament monitor lamp does not light up after the [FILAMENT] control has been turned beyond the 11 o'clock position, the filament has been burnt out and must be replaced with a new one.
   2. The waveform usually rises as A → B → C → D. In the case of new filaments, however, the first peak sometimes gets higher than the second as A → D → C → B.
   3. If the control is turned beyond the 3 o'clock position, the filament may be overheated and burnt out.
   (5) Turn back the [FILAMENT] control slightly so that the waveform comes immediately prior to the second peak.

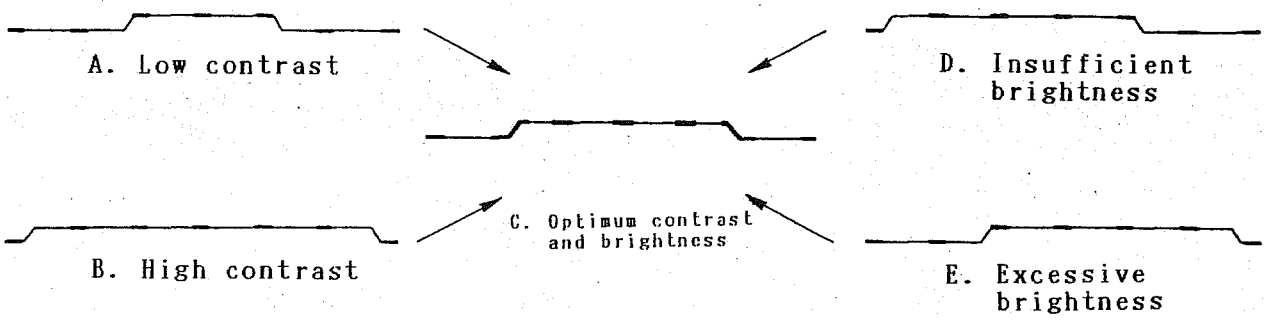
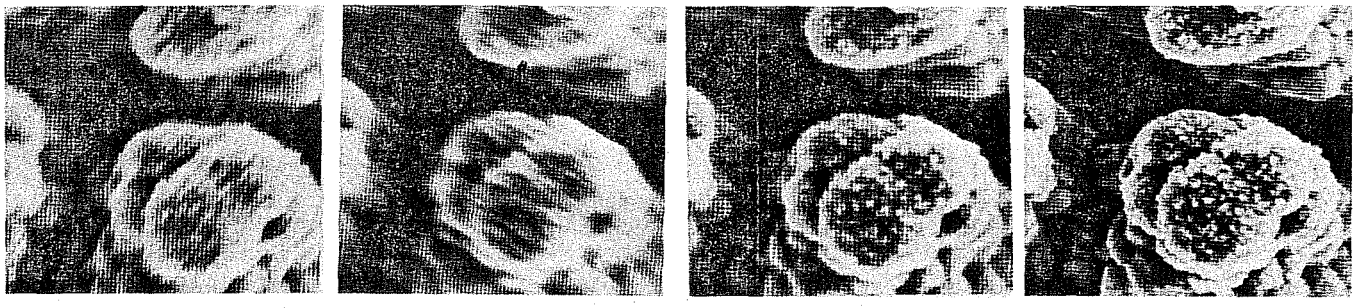


Fig. 3-11 Rapid Exposure Marker

7. Set magnification below 500× with the [MAGNIFICATION] switches and press the SCANNING MODE [PIC1] .
   When the contrast and brightness are in good exposure, go to step 10.
8. Press SCANNING MODE [EXP] to show the exposure marker.
9. Adjust contrast and brightness properly with the [CONTRAST] and [BRIGHTNESS] controls. (Refer to Fig. 3-11)
10. Press the SCANNING MODE [TV] and set 12 - 3 o'clock position with the [SPOT SIZE] control to observe TV images.
11. Focus with the FOCUS [COARSE] switches.
12. Set the magnification to the desired value.
13. If the desired magnification exceeds approx. 10,000×, adjust the focus further with FOCUS [FINE] control.
    Note: If astigmatism exists, the image may be often blurred image, even if the focus is adjusted.
    If the focus is changed at this time,
    1. At low magnification ..... the image blurs much more.
    2. At high magnification .... the image blurs unidirectionally.
    In case of such a phenomenon, correct astigmatism.

3.4.4 Astigmatism Correction



a b c d

Fig. 3-12 Astigmatism Correction

No astigmatism correction is needed in ordinary operation with stigmator memory. Set 12 o'clock position with the STIGMATOR X and Y controls. The amount of astigmatism may be increased with some specimens. In such a case, correct astigmatism with the following operation.

1. Low Magnification (below 5,000×)
   (1) Adjust the focus most finely with the STIGMATOR [X] and [Y] controls.
   (2) Adjust focus with the FOCUS [COARSE] and [FINE].
2. High Magnification (above 5,000×)
   (1) Turn the STIGMATOR [X] control largely clockwise and/or counter-clockwise. Ensure the changing image blurring (direction of astigmatism) (refer to Fig. 3-12a,b) and set it with the [X] control at the medium direction of image blurring. (Refer to Fig. 3-12c)
   (2) Adjust it also with the [Y] control as same as the [X] control.
   (3) Readjust focus with the FOCUS [COARSE] and [FINE].
3. When Astigmatism correction is hard:
   (1) Repeat the above operation a few times if it is not easy to correct astigmatism.

3.4.5 Flat Panel Key Operation

1. Key arrangement

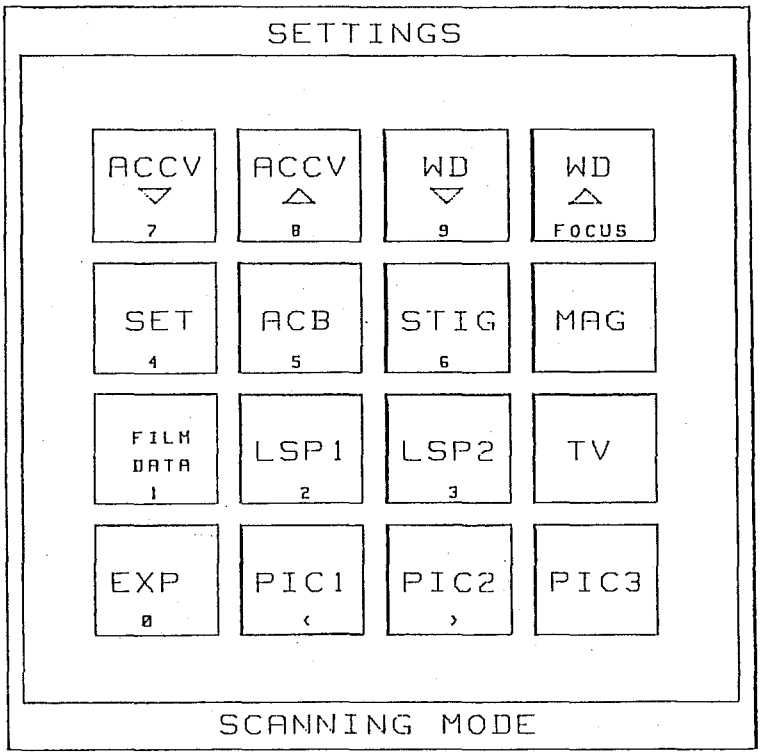
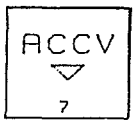
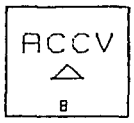


Fig. 3-13 Flat Panel Key (Keypad)

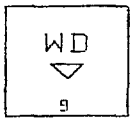
2. Description of keys
Normally, the upper function of each key is used in its independent operation and its lower function is used in the [SET] mode generally.
. SETTING: for changeover of accelerating voltage, working distance, memory functions and film data



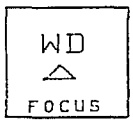
Accelerating voltage DOWN key
Accelerating voltage lowers each time the key is pressed. Pressing in succession, repeat to down the accelerating voltage.



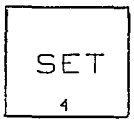
Accelerating voltage UP key
Accelerating voltage rises each time the key is pressed. Pressing in succession, repeat to up the accelerating voltage.



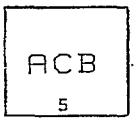
Working distance (WD) DOWN key
WD becomes longer each time the key is pressed.



Working distance (WD) UP key
WD becomes shorter each time the key is pressed.
This key is used following the [SET] key to memorize FOCUS current.
(When this key is kept pressed for more than two seconds, the FOCUS COARSE current is returned to the initial setting.)



ACB, STIG, MAG, FILM DATA set key



ACB set key
This is used following the [SET] key to allow the ACB operation reference value to be changed to the desired value.
The marker displayed in the EXP mode is used as the reference.
(Normally, the setting is carried out in the EXP mode. When it is kept pressed for more than two seconds, the buzzer sounds and ACB is set to the reference value.)

STIG set key
This is used following the [SET] key to memorize the STIGMATOR value at the AccV and WD in use.
(When you keep pressing this key for two seconds in the normal mode that the [SET] key is not pressed, the buzzer sounds and the memory value is released.)

MAG set key
Used following the [SET] key to preset the VIEW MAG value.

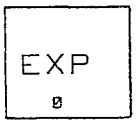
FILM DATA set key
Each time this key is pressed in the [PIC1] mode (the [SET] key is not pressed), the backgrounds of the data indication sections on the CRT screen and photo can be changed from ⌜Image⌟ → ⌜BLANK⌟ → ⌜OFF⌟.
When this key is used following the [SET] key, it can input the film number.

. SCANNING MODE: for changeover of scanning mode/speed

Horizontal line scanning on the CRT
(scanning speed: 50 ms)

Horizontal line scanning on the CRT
(scanning speed: 10 s)

TV scanning (CRT full size TV image; scanning speed:
EIA ... 16.6 ms CCIR ... 20.0 ms)



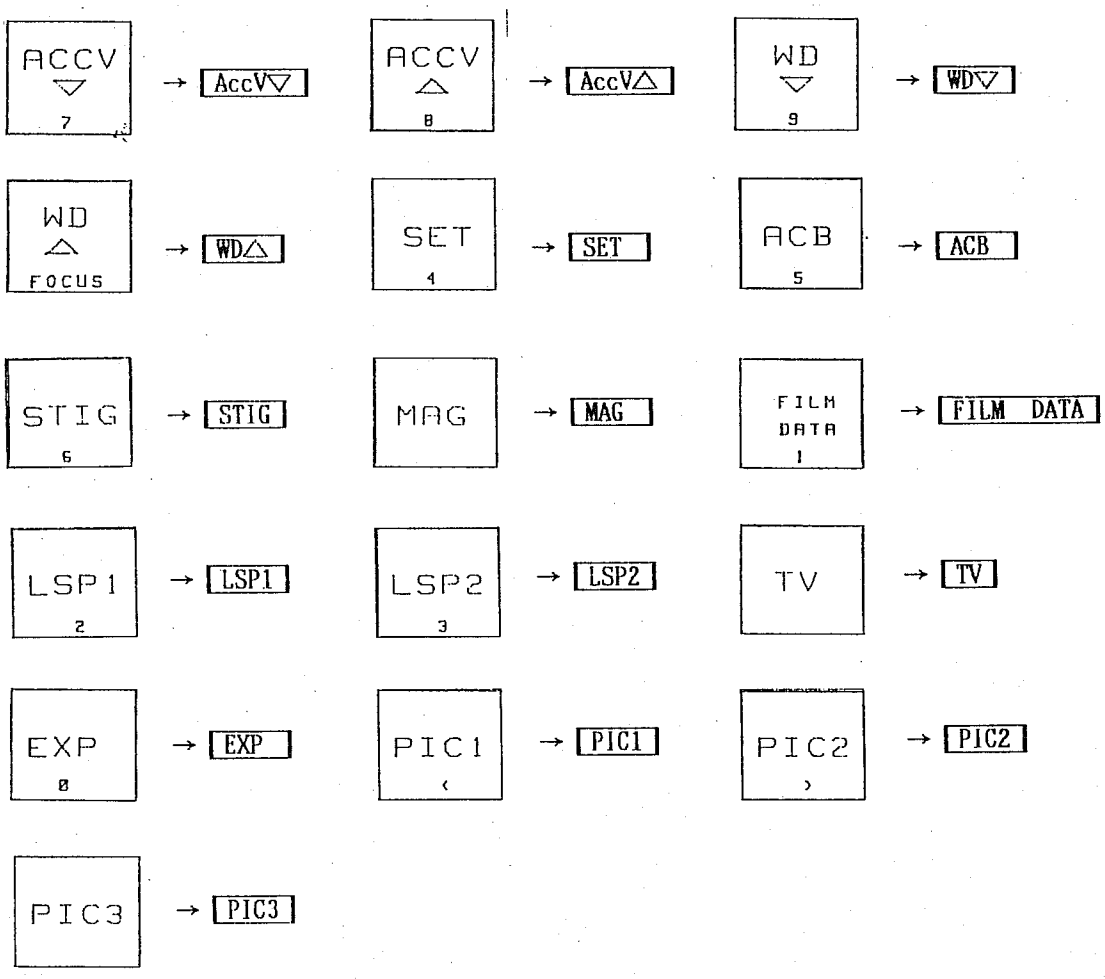
Display of Rapid Exposure Marker
(except when setting STIG)

Area scanning for ordinary image observation (CRT photo size; Scanning speed: 0.36 s)
Character display (accelerating voltage, magnification, micron marker, micron value, film number)
[<] is used following the [SET] and [FILM DATA] keys to shift the cursor left by one digit of the film number set (one press of this key moves the cursor left by one digit).

Area scanning for ordinary image observation (CRT photo size; Scanning speed: 3 s)
[>] is used following the [SET] and [FILM DATA] keys to shift the cursor right by one digit of the film number set (one press of this key shifts the cursor right by one digit).

Area scanning for ordinary image observation (CRT photo size; Scanning speed: 10 s)

Note: The flat panel keys appearing in this manual use the following abbreviations:


ACCV ▽ 7 → AccV▽
ACCV △ 8 → AccV△
WD ▽ 9 → WD▽
WD △ FOCUS → WD△
SET 4 → SET
ACB 5 → ACB
STIG 6 → STIG
MAG → MAG
FILM DATA 1 → FILM DATA
LSP1 2 → LSP1
LSP2 3 → LSP2
TV → TV
EXP 0 → EXP
PIC1 ‹ → PIC1
PIC2 › → PIC2
PIC3 → PIC3

3. How to use SETTINGS functions

Pressing the [SET] key will display "SET" on the upper left corner of the LCD and the system becomes ready for functional expansion and wait for keying in. After about 10 seconds, however, the SET mode is automatically released.

3.1 Accelerating voltage (AccV) setting

Accelerating voltage is selected according to the type of specimen and observation purpose.

(1) Accelerating voltage is increased/decreased each time the [ACCV△] / [ACCV▽] key is pressed.
(Digitally displayed on LCD)

Notes:
- At the time of start-up, accelerating voltage is set to the previously used value.
- When changing the accelerating voltage, the objective lens hysteresis elimination function operates interlockingly. (OL RESET)
- Changeover of accelerating voltage between 2 kV and 5 kV requires about one second because of a gun bias changeover delaying circuit.

3.2 Working distance (WD) setting

The working distance is adjusted to the specimen height.

(1) Each time the [WD△] / [WD▽] key is pressed, the working distance is made shorter/longer.
(Digitally displayed on LCD)

Notes:
- At the time of start-up, the working distance is set to the previously used value. (It is set to 20 mm when shipped.)
- At the time of manual changeover of working distance, the objective lens hysteresis elimination function operates interlockingly. (OL RESET)
- When the working distance is changed at minimum magnification, the magnification may change. (Minimum magnification: ×50 at WD = 10 mm, ×35 at WD = 20 mm, ×15 at WD = 48 mm)
- When Automatic Focusing Device (AFD) is used, the working distance is automatically set.

3.3 Automatic Contrast and Brightness Control (ACB) setting

This is used when desiring to change the operating reference value of ACB.

(1) Press the [EXP] key. (Rapid Exposure Marker is displayed.)
(2) Using the manual knob on the control panel, set the contrast and brightness to be set in memory.
(3) Following the [SET] key, press the [ACB] key.

Note: When you keep pressing (more than 2 seconds) the [ACB] key following the [SET] key till the buzzer sounds, the operating reference value of ACB returns to the standard value.

3.4 Astigmatism correction (STIG) setting
The preset value for astigmatism correction can be changed for each combination of the accelerating voltage and working distance.

. Method I (manual preset mode)
(1) Adjust the focus at the accelerating voltage and working distance to be set. (Carry out astigmatism correction when focusing is difficult because of large astigmatism.)
(2) Following the [SET] key, press the [STIG] key. (Astigmatism may be deviated.)
(3) After correcting the astigmatism using the manual [X] / [Y] knob, press the [SET] key. Then the STIG setting is completed.

. Method II (ASD preset mode)
(1) Adjust the focus at the accelerating voltage and working distance to be set. (Carry out astigmatism correction when focusing is difficult because of large astigmatism.)
(2) Following the [SET] key, press the [STIG] key. (Astigmatism may be deviated.)
(3) Pressing the STIGMATOR [AUTO] start switch on the control panel actuates ASD, with the following display appearing on LCD.
STIG SET OK? END = SET Key, ASD = Auto Key
MAN = STIG Key
(4) In this state, fine adjustment can be carried out using the STIGMATOR manual [X] / [Y] knob.
(5) After completion of fine adjustment, press the [SET] key.
. When suspending: Press the [STIG] key. The system will return to the manual preset mode.
. When adjusting with ASD: Press the STIGMATOR [AUTO] start switch.
Note: Both in the manual preset mode and the ASD preset mode, the SET mode is automatically released when there is no key input or no correcting-operation for 25 seconds.
(6) When returning the corrected value to the standard one, STIG can be reset.
. For STIG resetting, keep pressing the [STIG] key for two seconds till the buzzer sounds, in the ordinary mode (with SET no indicated on LCD).

3.5 Magnification (MAG) setting

Merely by pressing the [VIEW] switch on the control panel, the magnification is instantaneously changed to the desired set value from any magnification.

(1) Using the magnification selection switches on the control panel, set the magnification to the desired value.
(2) Following the [SET] key, press the [MAG] key. (The magnification set in (1) is stored in memory.)
(3) Pressing the [VIEW] switch changes the magnification to the value set in (1). (The LED of the [VIEW] switch lights up.)

Notes:
- Pressing the [VIEW] switch again with the LED of the [VIEW] switch ON changes the magnification to the previous value. (The LED of the [VIEW] switch goes out.)
- When changing the set magnification, repeat the steps (1) and (2) again.
- In the SET mode (LCD indicates "SET"), the magnification selection switch on the control panel does not operate.
- At the time of start-up, the magnification is set to the value used previously. (The magnification set at the time of shipping is ×100.)

3.6 Focus setting

Normally, the objective lens current is stored in memory for each combination of the accelerating voltage (7 steps; from 1 to 25 kV) and working distance (3 steps: 10, 20, 48 mm).
Therefore, the image is focused the moment the accelerating voltage or working distance is changed. However, because of the specimen height (thickness), if the working distance is deviated from 10/20/48 mm, the image is out of focus, so focus must be adjusted.
The FOCUS setting is used only in such a case.

(1) Adjust the focus with the FOCUS [COURSE] switch/ [FINE] knob on the control panel.
(2) Press the [SET] [WDΔFOCUS] keys in succession. (When you keep pressing the key for more than 2 seconds, the buzzer sounds and the FOCUS COARSE current is returned to the initial setting.)

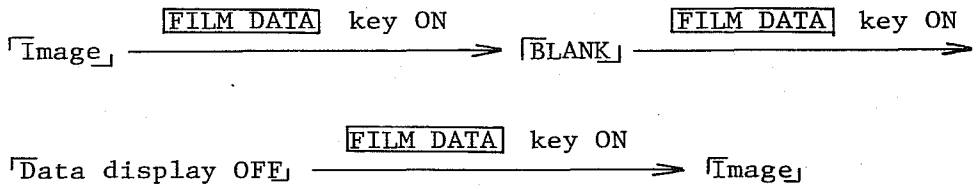
Note: If the working distance is deviated from 10/20/48 mm, an error may be caused in the magnification. Adjust the specimen height (thickness) as close to the upper surface of the specimen stage as possible.

3.7 FILM DATA setting

The film number (6 digits) convenient for filing photos can be input from the keypad. The film number can always be displayed on the LCD, but on the observation CRT it is displayed only in the SCANNING MODE [PIC] and at the time of photographing.

(I) Selection of film data printing mode

Each time the SETTINGS [FILM DATA] key is pressed, the backgrounds of the data indication selections on the CRT screen and photo change as follows:



(II) Types of LCD indications of film number

. Indication panel [COUNT] switch ON

LCD indication: □□□□ □□

Auto count

. Indication panel [COUNT] switch OFF

LCD indication: □□□□□□

(III) How to input film number

(1) Following the [SET] key, press the [FILM DATA] key.
(The cursor blinks at the leftmost digit of the LCD film number.)

(2) Press a numeral key (a numeral is inscribed at the lower portion of each key.)
(Enter a numeral at a position where the cursor blinks.)

(3) The input of numerals starts at the leftmost digit of the LCD indication and moves to the right each time a numeral key is pressed.

(4) To move a digit during film number input

[PIC1<] key: The cursor moves left by one digit each time this key is pressed.

[PIC2>] key: The cursor moves right by one digit each time this key is pressed.

(5) Pressing the [PIC1<] key at the leftmost digit releases the film data set.

(6) Pressing a numeral key or the [PIC2>] key at the rightmost digit completes the film data set, releasing the [SET] mode.

Notes: . [SHUTTER] switch does not operate in the SET mode. Press the [SHUTTER] switch after releasing the SET mode.

. Counter reset function
Following the [SET] key, press the [COUNT] key on the display panel, and the two right digits of the film number becomes [0] [0]. (Resetting can be carried out regardless of counter ON/OFF.)

(IV) Input example of film number

. Example 1) When inputting [1] [2] [3] [4] [5] [6].

(1) Following the [SET] key, press the [FILM DATA] key. (The cursor blinks at the leftmost digit of film number on LCD.)

(2) Press the [FILM DATA 1] [LSP1 2] [LSP2 3] [SET 4] [ACB 5] [STIG 6] keys in succession.

. Example 2) Suppose [1] [2] [3] [4] [5] [6] are set. When changing the third digit from left [3] to [0].

(1) After pressing the [SET] and [FILM DATA] keys,

Press the [PIC2 >] twice. (Bring the cursor to the digit you wish to change.)

(2) Press the [EXP 0] key. (Input [0] to the cursor position.)

(3) Press the [PIC1 <] key three times or the [PIC2 >] key four times and remove the cursor.
This completes film number input. (SET mode is released.)

(V) Automatic counting of film number

. When the [COUNT] switch on the display panel is at ON. (The film number indication on LCD is □□□□ □□ .) Following the [SET] key, press the [FILM DATA] key. Each time the [MAG] key is pressed, the film number indication on LCD changes alternately as follows.

□□□□ □□
space (no mark)

When the [SHUTTER] switch is ON, the count increases. (NOR)

□□□□_□□
space (a bar shown)

When the [SHUTTER] switch is ON, the count decreases. (REV)

3.4.6 Liquid Crystal Display (LCD)

The observation conditions are indicated in the upper lines on LCD (40 columns × 2 lines, with LED backlight), and informations such as evacuation sequence, check data, photo time and warning are indicated.

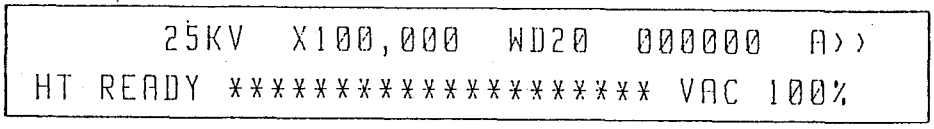


Fig. 3-14 Liquid Crystal Display

1. Observation conditions

Accelerating voltage	:	1, 2, 5, 10, 15, 20, 25 kV (7 steps)
Working distance	:	10, 20, 48 mm (3 steps)
Magnification	:	15 to 200,000× (25 steps)
Film number	:	6 digits [COUNT] switch ON : □□□□ □□ [COUNT] switch OFF: □□□□□□
Indication linked with Automatic Contrast and Brightness Control (ACB)	:	When [A] is indicated at the right of film number, it means linkage with ACB.
Photo speed indication	:	[>] in case of normal photographing. [>>] in case of quick photographing.

2. Evacuation sequence

[DP WAIT]	:	Oil diffusion pump (DP) oil being heated (about 20 min.) at start-up.
[VENT]	:	Column being at the atmospheric pressure. (admitting air into the column.)
[PRE EVAC]	:	Column being pre-evacuated.
[EVAC]	:	Column being evacuated.
[HT READY]	:	High tension (Accelerating voltage) ready for application.
[HT ON]	:	High tension (Accelerating voltage) being applied.

3. Photo time
With the SHUTTER ON, the indicated figures of the photo time gradually decreases from 100 to 0. (The bar gradually goes out.) Now, photographing is completed and the indication returns to original. The indicated figures of the photo time does not indicate seconds, but simply the photographing time divided by 100.

4. Check data
Various check data is indicated by manual checker and auto checker. (As for indicated contents, refer to 3.4.7 Checkers.)

3.4.7 Checkers

These checkers allow manual or automatic checking of the power supply system, to facilitate maintenance and servicing. Normally, they can be used as monitors for vacuum or load current.

1. Manual checker
   Check items are selected using the [CHECK SELECT] switch on the display panel.
   The following items are endlessly indicated on LCD.

Items	Description	Unit	Standard value
L.C	Filament load current	μA	80 to 120 (25kV) (*1)
VAC	Vacuum	%	0 to 100
PMT	Applied voltage of photomultiplier	V	400 to 700 (*2)
ICL	Condenser lens current	mA	400 to 450 (*3)
IOL	Objective lens current	mA	560 to 570 (*4)
AC	Power supply voltage	V	100
EXT1	For attachment	%	(*5)
EXT2	For attachment	%	(*5)
EXT3	For attachment	%	(*5)

*1: The load current increases at filament spacer thickness 2.0 mm (2 mark lines) and decreases at 2.2 mm (4 mark lines). Usually, a 2.1 mm spacer (3 mark lines) is used.
*2: Changed using the [CONTRAST] control knob. (AccV = 25 kV, [SPOT SIZE] control knob in the 11 o'clock direction.)
*3: AccV = 25 kV, [SPOT SIZE] control knob in the 11 o'clock direction.
*4: AccV = 25 kV, WD = 20 mm
*5: Changes with the type of attachment.

. Vacuum monitor:
[VAC] indicates the evacuation state of the column.
At time of [VENT] (when column is at the atmospheric pressure) : approx 0%
Note: Even when column is at the atmospheric pressure, VAC several % may be indicated.
[PRE EVAC] → [EVAC] : approx 25%
At HT READY : approx 100%

. Load current monitor:
[L.C] indicates the filament heating state.
1) Following values are obtained as reference at accelerating voltage 25 kV. (in a new filament)
80 μA or less ..... Undercurrent (insufficient heating)
80 to 120 μA ..... Normal use
120 μA or more .... Overcurrent (excessive heating)
Notes: . Saturation point of filament progresses to counter-clockwise direction and the filament load current decreases, as it is used.
The filament used for long time is required to set at a saturation point each time when it is used.
. When accelerating voltage is changed lower, the above values at saturation point decrease.
. Filament life is longer if it's load current is lessened.

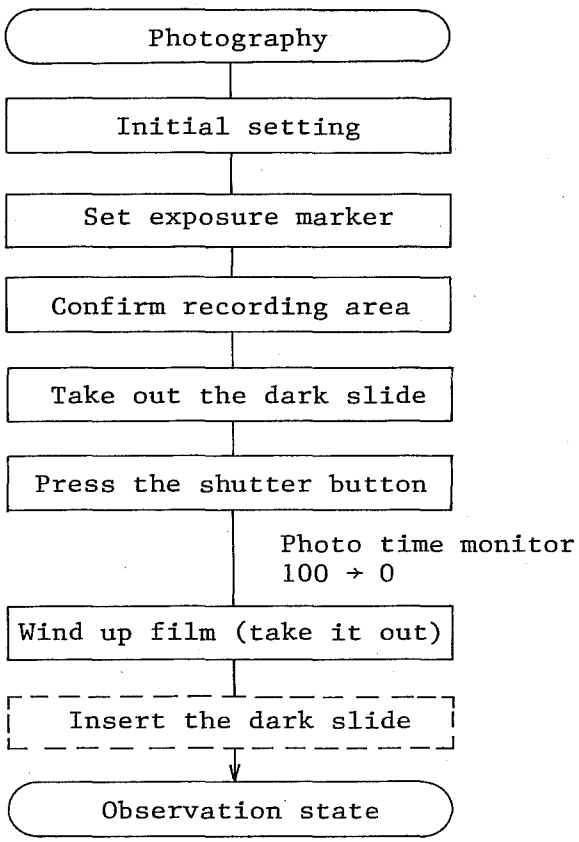
2. Auto checker
If the following items (power supplies) fluctuates beyond ±10%, the LCD indication flickers and warns abnormalities in the SEM to operator.
. WARNING indication items;

[CHECK POWER SUPPLY]	:	Power supply (AC100V)
[HT TROUBLE]	:	DC power supply for high tension
[SCAN TROUBLE]	:	DC power supply for scanning system
[CALL SVC ENGINEER]	:	At abnormal time of the above two or more items

. OVER LOAD CURRENT indication;
When the filament load current exceeds 150 μA, the LCD indications of [L.C 150 μA] and [OVER CURR] flickers alternately. Set the [HT] switch to OFF and press the [VENT] switch. Confirm the top of filament after dismounting.
. When the warning is indicated on LCD;
If the [SET] key and the [CHECK SELECT] key on display panel are pressed in succession, the description of warning is indicated. (only one item)

3.5 Photography

3.5.1 Ordinary Photography



1. Initial settings
   Ensure the followings after adjusting the focus of image at the observation state.
   - Photo speed > : For normal photographing
     >> : For quick photographing
   - Film number : Set with the [SET] and [FILM DATA] keys.
     Last 2 digits
     Manual count : [COUNT] switch OFF
     LCD indication ☐☐☐☐☐☐
     Automatic count : [COUNT] switch ON
     LCD indication ☐☐☐☐ ☐☐
   - Power switch ON for CSI3 and CSI6
   - Shutter speed of CSI3 camera at B
   - Set up the aperture value of CSI according to the film (Exposure marker standard)

Film Sensitivity		Recording CRT, ultrahigh-resolution CRT-UHR; NOR mode Aperture value (CSI3)	Ultrahigh-resolution CRT-UHR; UHR mode Aperture value (CSI3)
ISO	DIN		
50	18	F8 (f11)	——
75 ∿ 100	20 ∿ 21	F11 (f16)	——
200	24	F16 (f22)	——
400	27	F22 (——)	F8 (F11): Develop in 4× sensitivity
3,000	36	ND4 filter + f22 (——)	f11 (f16)

Table 3-4 Relation between film sensitivity and aperture of CSI

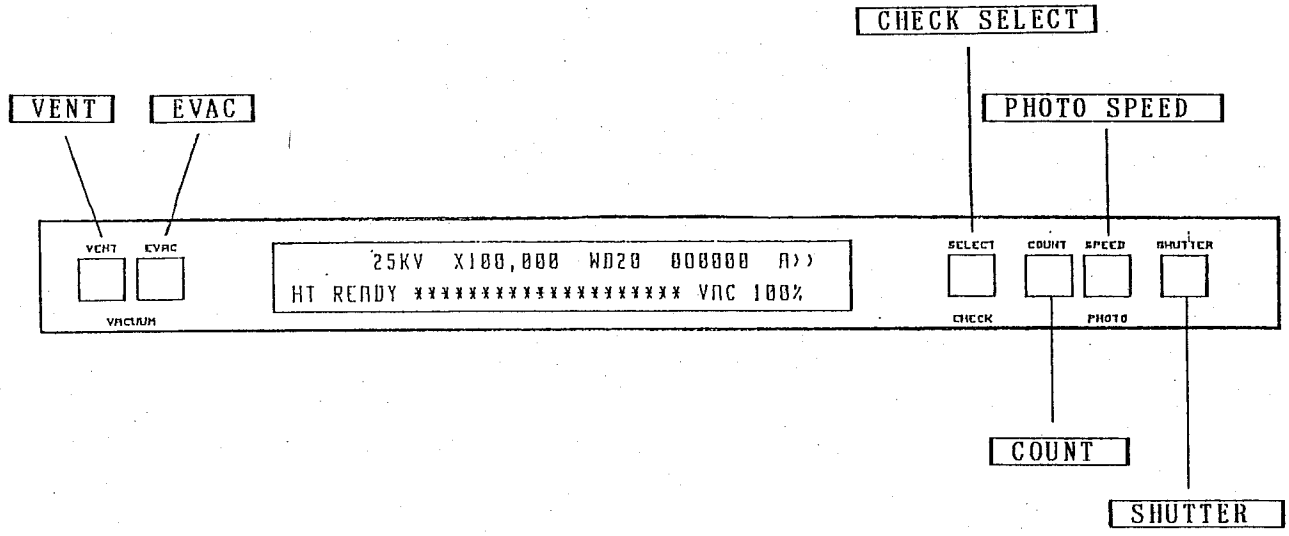


Fig. 3-15 Display Panel

2. Set the exposure marker or use the ACB.
3. Press the SCANNING MODE [PIC1] / [PIC2] / [PIC3] and confirm the recording area.
4. Make sure that the Camera for Scanning Image (CSI) is fixed with latch.
5. Take the dark slide out of the film holder if it is inserted (CIS3 has no dark slide).
6. Press the shutter button (either [SHUTTER] or CSI automatic shutter).
   Note: Do not apply any vibration nor impact to the microscope during photographing process.
7. After the indicated figure for the photo time gradually, decreases from [100] to [0] (The bar gradually goes out.), the shutter closes and exposure completes, wind up the film (or take it out).
   Here, CSI3 and CSI6 wind it up automatically.
8. Insert the dark slide for removing the Camera for Scanning Image (CSI) or if it takes a long time until next photography.

3.5.2 Multi Exposure Photography

The following methods allow to photograph in piles the line profile of an element on the SEM image with an Energy Dispersive X-ray Spectrometer (EDS: option).

(I) CSI1/CSI2/CSI5

- Photograph in piles such as line profile after photographing the SEM image. (without winding/extracting film)

(II) CSI3

1) If the recording CRT(PRD1/UHR) is installed;
   - Turn off the PSC power supply during the first time photography.
     - No automatic winding of film.
     - Do not dismount camera from the recording CRT since camera shutter is opened.
   - Before going into the second exposure of line profile, etc., turn on the PSC power supply. When making more than two exposures, turn on the PSC power supply before doing the final exposure.
     - Film is wound up automatically when the photographing ends.
2) In case of using the CRT for both observation and photography;
   - Secure the rewind lever firmly to the camera with gun tape, etc.
   - Turn on the PSC power supply.
   - Carry out the first exposure of the SEM image, etc., while pressing the rewind button located under the camera.
     - Film is not wound up when the camera shutter closes.
   - Remove the gum tape, etc. securing the rewind lever.
   - Carry out the second exposure of the line profile, etc.
     - Film is wound up automatically when the photographing ends.
   - When making more than two exposures, remove the gum tape before doing the final exposure.

   Notes:
   - If the rewind lever is not firmly secured, film may wind up a little and the multiple exposure image may be shifted.
   - In case of using the CRT for both observation and photography, avoid as much as possible multiple exposure with CSI3.

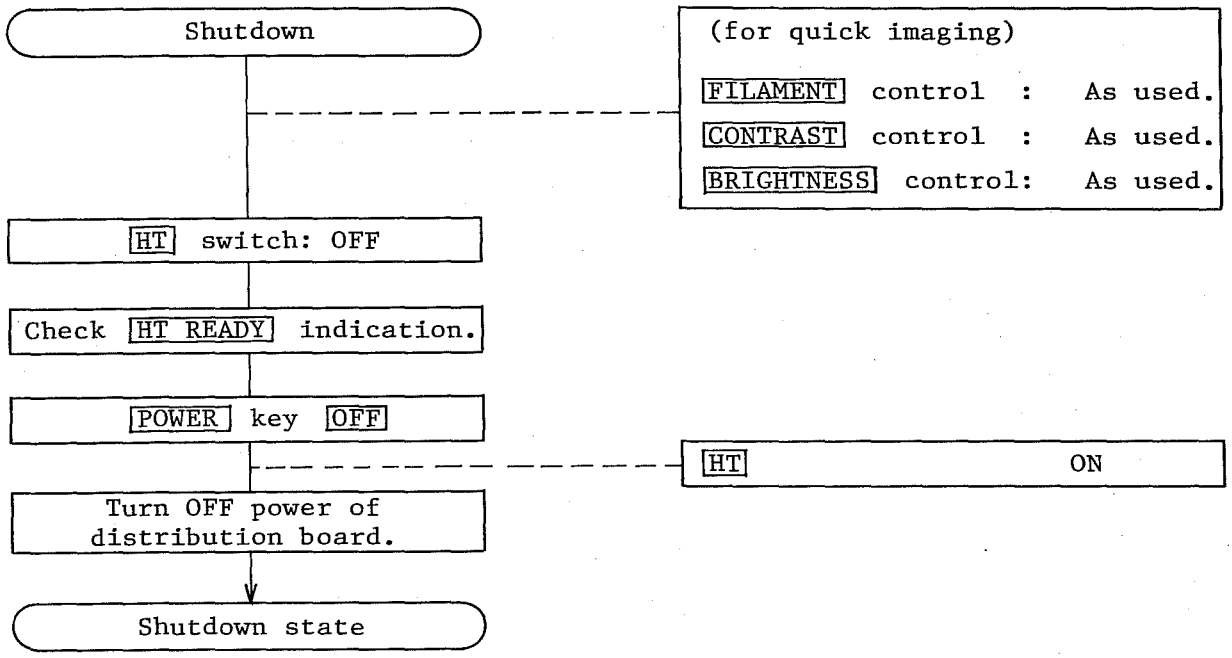
(III) CSI6

. Turn off the power supply switch on the camera back.
. Carry out the first exposure of the SEM image, etc.

  . No automatic winding of film.
. Before going into the second exposure of line profile, etc., turn on the power supply switch on the camera back.
. When making more than two exposures, turn on the power supply switch on the camera back before doing the final exposure.

  . Picture is automatically sent out when the photographing ends.

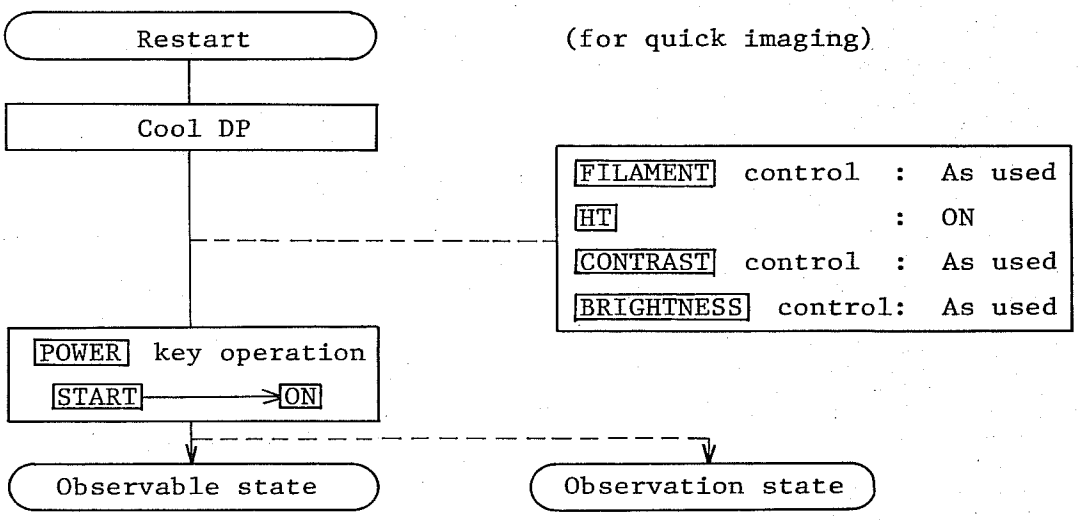
3.6 Shutdown



Start from the step 1 when images are obtained immediately only by starting the system.
Start from the step 2 just to shutdown the system.

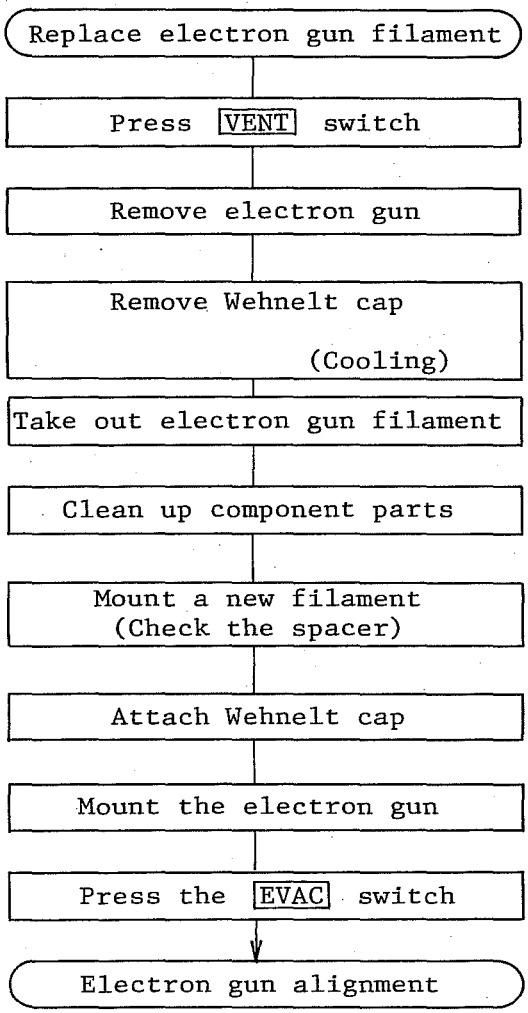
1. For quick imaging, make the settings as follows.
   - FILAMENT control : As used
   - CONTRAST control : As used
   - BRIGHTNESS control : As used
2. Set the HT switch to OFF. (LED goes out.)
3. Make sure that the HT READY sequence is indicated on LCD.
4. Turn the POWER key switch to OFF. (The key can be pulled out.)
5. Set the HT switch to ON (for quick imaging).
6. Turn OFF the power switch on the distribution board, and close the tap.
   Notes: 1. Even if cooling water is stopped right after turning off the power of the system, no troubles may result. However, keep supplying water until the heater of the oil diffusion pump (DP) cools down to room temperature (approx. 10 to 15 min.)
   2. The system will not start again if the oil diffusion pump (DP) is not cooled to room temperature. (Refer to Restart.)

3.7 Restart



1. For restart after water failure, wait until DP cools down to the room temperature (do not turn the power ON until DP cools down to the reset temperature).
2. For quick imaging, make the settings as follows.
   - FILAMENT control : As used
   - HT switch : ON (LED ON)
   - CONTRAST control : As used
   - BRIGHTNESS control : As used
3. Turn the POWER key switch to ON from START after recovering from power or water failure.

3.8 Electron Gun Filament Replacement



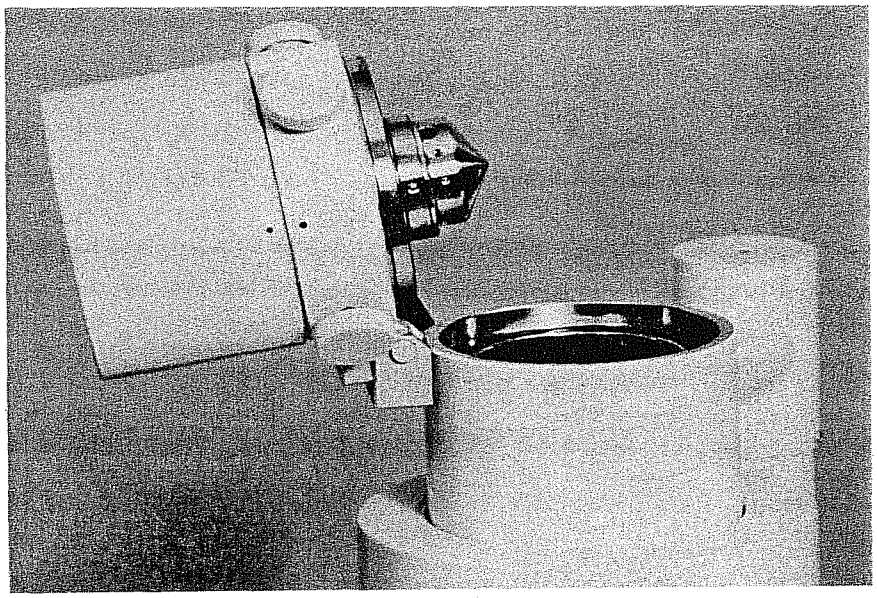
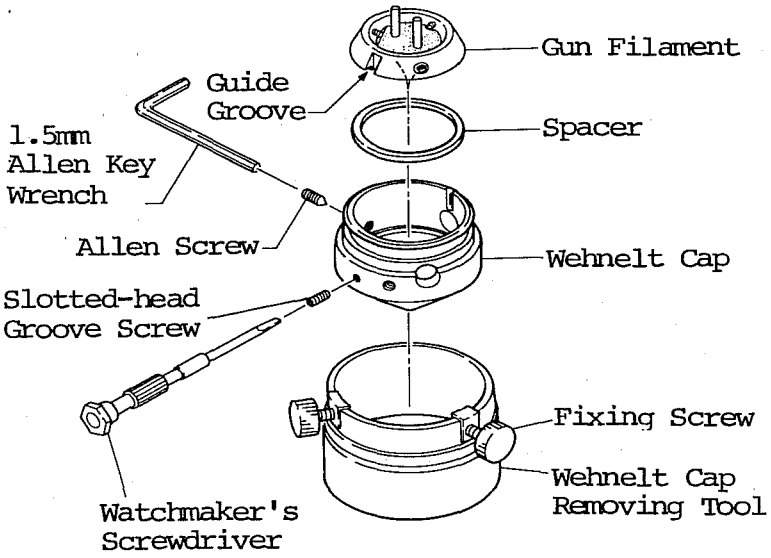


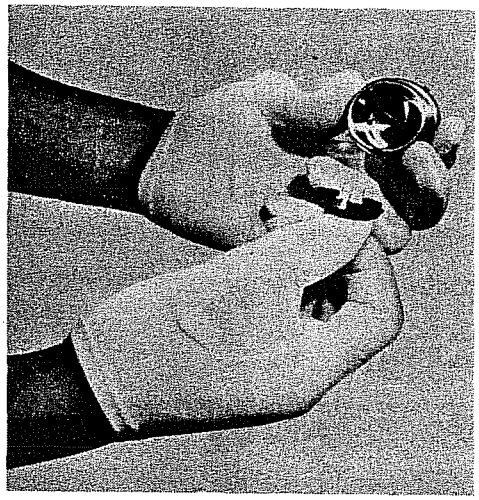
Fig. 3-16 Electron Gun Removal

If the filament monitor lamp does not light up even when [FILAMENT] control is turned beyond the 11 o'clock position, it indicates the electron gun filament is burnt out. In such a case, replace it by following the procedure described below:

1. Admit air into the column to atmospheric pressure (by pressing VACUUM [VENT]).
2. Open the electron gun. (Refer to Fig. 3-16)
   Note: Since the filament replacement exposes the column and specimen chamber to the atmosphere, perform the replacement work in as short a time as possible by observing the procedure.
3. Put the Wehnelt cap removing tool over the Wehnelt cap and secure them with fixing screw.
   Note: Be careful to handle the Wehnelt cap, as the used Wehnelt cap is highly heated.
4. Remove the Wehnelt cap from the Wehnelt unit base by pulling the tool upward and cool the cap down sufficiently.



a



b

Fig. 3-17 Filament Removal

5. Loosen 2 fixing screws and remove the Wehnelt cap removing tool from the Wehnelt cap.
   Loosen 3 Allen screws of Wehnelt cap with an Allen key wrench.
6. Loosen the slotted-head grooved screw with a watchmaker's screwdriver and take out the electron gun filament (refer to Fig. 3-17a).
7. Clean up the insulator surface of electron gun.
8. Close the electron gun (here, keep evacuating if cleanup job takes a time).
9. Clean up Wehnelt cap.

(Comments)
Allen screw : For filament centering
Slotted-head grooved screw: Adjusting filament direction

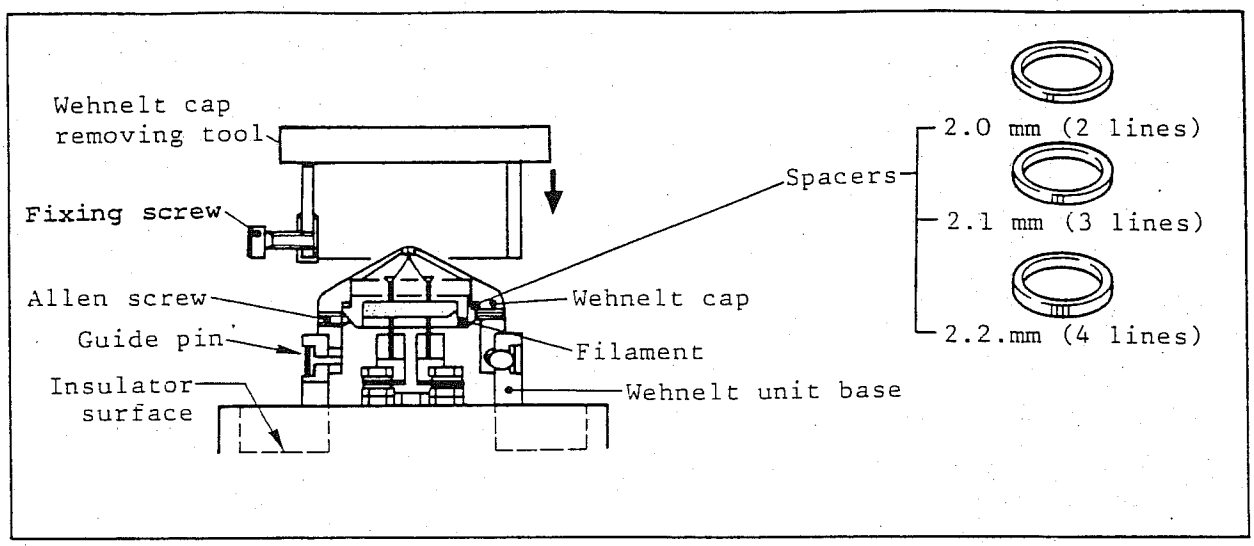
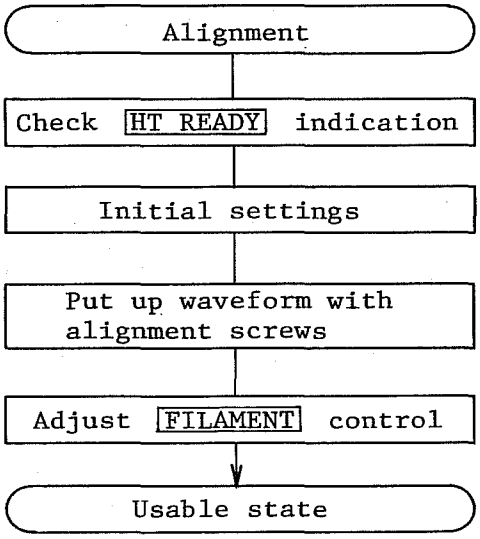


Fig. 3-18 Installing Wehnelt

10. Install a new electron gun filament to the wehnelt cap by aligning it's guide groove with the pin, and secure it by tightening the allen screws (three) and the slotted-head grooved screw.
    Note: . Usually, a 2.1 mm spacer (3 mark lines) is set so that the tip of the electron gun filament is about 0.2 mm short of the wehnelt cap.
    If the tip of the electron gun filament protrudes from the wehnelt cap when a 2.1 mm spacer is used, employ a 2.2 mm spacer (4 mark lines).
    . A 2.2 mm spacer is suited to keep longer the life of filament since it depends on the load current.
    A 2.0 mm spacer is suited to observation under high brightness and high resolution.
11. Align the guide pin of wehnelt with the pin groove and push down the wehnelt cap onto the wehnelt unit base.
    (The above procedures is performed after vent the column and open the electron gun.)
12. Blow away dust and lint around the wehnelt unit with a handblower and mount the electron gun on the column.
13. Evacuate the column again. (press the VACUUM [EVAC] switch.)
14. Press the [HT] switch when the evacuation sequence [HT READY] on LCD is indicated, and turn the [FILAMENT] control knob to the 12 o'clock position. After about 10 min. of preliminary heating, perform alignment at the 2 to 3 o'clock position (refer to Fig. 3-9).
15. Set the [FILAMENT] control knob almost to the saturation point (refer to Fig. 3-22). After exchanging filament, readjust the [FILAMENT] control knob position every 10 min. for about one hour so that it's position goes into no oversaturation range.

3.9 Electron Gun Alignment



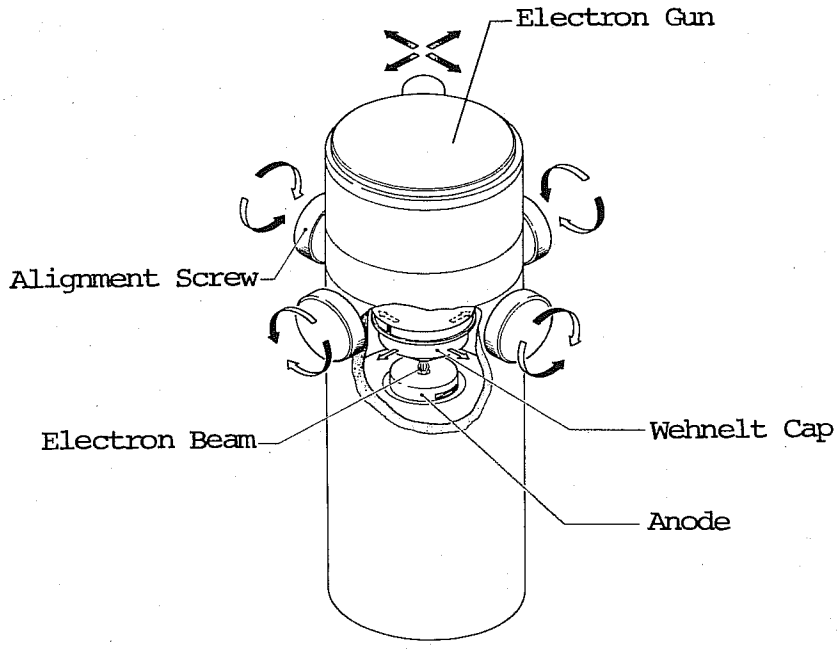


Fig. 3-19 Function of Alignment Screws & Electron Gun

Realignment is required for electron gun after replacing electron gun filament and objective lens aperture or cleaning them or disassembling column.

1. Press the VACUUM [EVAC] switch and check that the evacuation sequence [HT READY] on LCD is indicated.

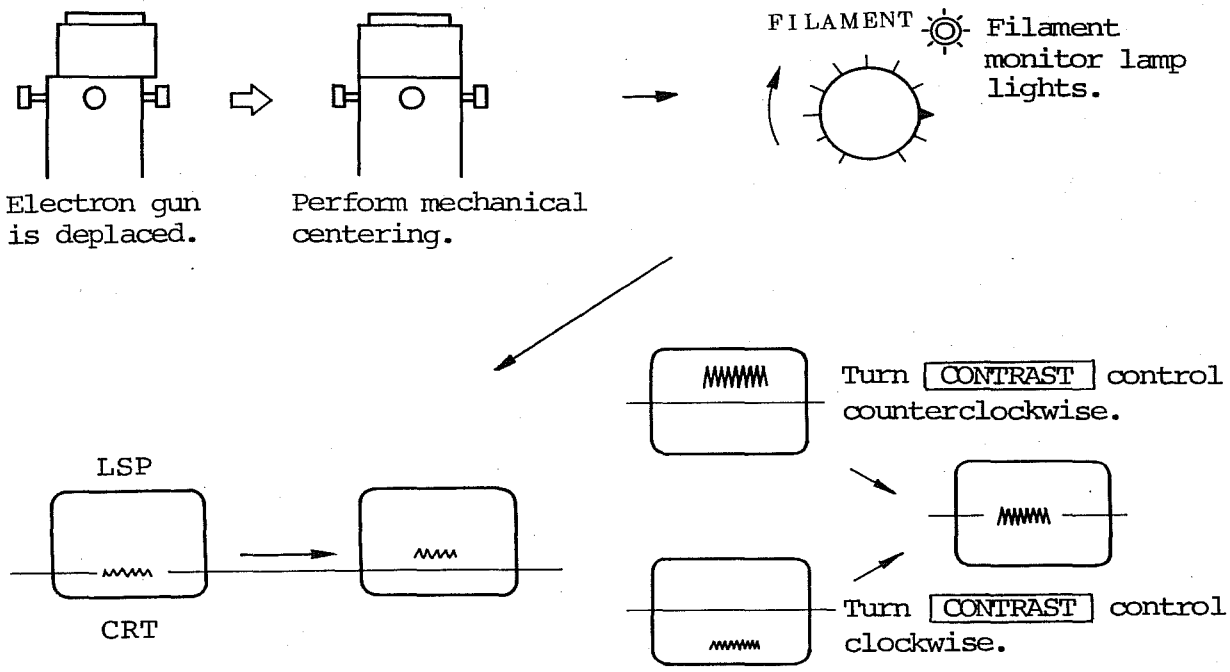


Fig. 3-20 Electron Gun Alignment

2. Align the electron gun mechanically with 4 alignment screws.
3. Follow the procedure below: (Initial setting)
   - HT switch ON (LED lights up)
   - ACCV key 25 kV
   - Press SCANNING MODE LSP1 key
   - Set BRIGHTNESS control to 11 o'clock position.
   - Set MAGNIFICATION switch above 5,000x.
   - Turn FILAMENT control to near the 3 o'clock position.
4. Ensure that the filament monitor lamp lights up.
   Note 1: If the filament monitor lamp does not light, the electron gun filament is burnt out and must be replaced.
   Note 2: If FILAMENT control is turned beyond the 3 o'clock position, the filament may be overheated and be burnt out.
5. Adjust the position of electron gun with 4 alignment screws so that the waveform on CRT is shifted to the uppermost position.
   Note: When the shift of the waveform is small, or is so large that the waveform reaches the upper limit of the screen, set the waveform to around the center with CONTRAST control.
6. Turn FILAMENT control back to 9 o'clock position.

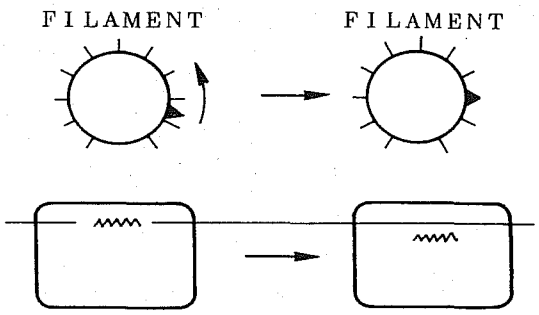


Fig. 3-21 [FILAMENT] Control Setting (I)

7. Set the usable position of [FILAMENT] control
   1 Check that the emission is close to the ideal curve shown in Fig. 3.9-4.
   2 Turn [FILAMENT] control slightly in the counterclockwise direction while monitoring the waveform on CRT and set the control to a position which is just before a sharp fall in waveform starts (slightly lower than the saturation point: A in Fig. 3.9-4).

   Note 1: The first peak and the saturation point heights vary with some filaments. In some new filaments, the first peak may be sometimes higher than the saturation point.

   Note 2: If axis alignment is insufficient, the waveform may drop from 3 o'clock position to appear a second peak.

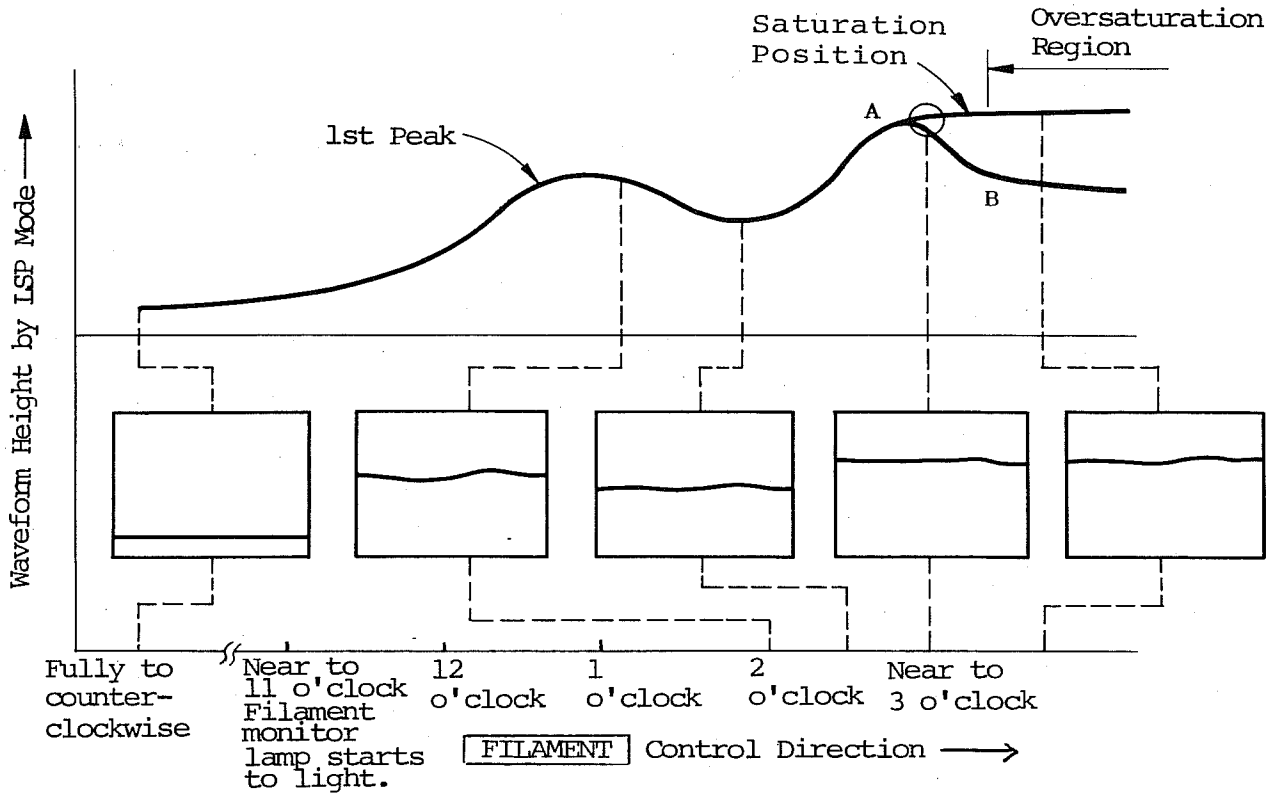


Fig. 3-22 FILAMENT Control Setting (II)

8. Set FILAMENT control again to its final position.
   Note 1: If electron gun filament is used in the over-saturation state, it shortens the life of electron gun filament and causes to warp it's top.
   Note 2: When the position of FILAMENT control is adjusted, select the L.C with the CHECK SELECT switch.
   1 Set it so as not to exceed 120 μA by selecting spacers.
   2 If the meter reading fluctuates, clean the wehnelt cap. If whiskers are observed on the filament, replace the filament with a new one (whiskers are discernible with a loupe of about 15×).

3.10 Specimen Preparation

Perform the specimen preparation for microscope with the following keypoints in mind:

- The specimen must be shaped so as to fit the specimen holder.
- The specimen must be secured firmly on the specimen stub and the specimen holder.
- The specimen itself must be conductive and also conductivity must be ensured between the specimen and specimen holder enough.

1. The specimens applicable to the microscope only after proper treatment. Since the specimen is examined in vacuum and is subject to electron beam irradiation, the specimen must be appropriately treated before introducing into the specimen chamber. Otherwise, satisfactory micrographs can not be obtained. Moreover, the microscope will be contaminated that requires to clean up the microscope each time it is used.
   a. Radioactive specimens
   b. Wet specimens (thick plant leaves, bulky soft animal tissues, etc.)
   c. Fine particles in volume; that is not secured.
   d. Magnetic materials
   e. Porous specimens, especially gas-absorbed specimens

   These specimens will evaporate, generate gas, take much time to evacuate by specimen dispersion or contaminate inside the column. Therefore, these specimens may cause astigmatism, deviation of electron beam probe in the magnetic field of specimens and make it impossible normally to observe these images.

2. Securing the specimen
   Use conductive paint such as silver or carbon to secure the specimen to the specimen mount. Additionally, double-sided adhesive tape, vacuum compound, methyl cellulose solution, manicuring solution and various other adhesives can also be used for securing the specimen to the mount.

3. Evaporation and sputtering
   The metallic specimen has conductivity itself and therefore it can be observed just by securing it to the specimen mount or the specimen holder with conductive paint. In the case of non-conductive specimens, coat the conductive film evenly onto the surface of specimens with vacuum evaporator or sputtering device, after securing them onto the specimen mount, to prevent any buildup of surface charge and reduce damage by thermal effect of the electron beam and further to improve the secondary electron yield rate. Desirable evaporation film thickness: 5 to 30 nm.

4. Coating materials for evaporation and sputtering
   . Vacuum evaporation material for complicated facial specimens
     Carbon: Continuous, not in aggregate form, uniform, highly evapolation in behind of micro structure
     Gold : Non-oxidization, extremely fine particles, low melting point, high secondary electron emission
   . Sputtering material
     Gold foil is generally used as electrode material for sputtering. In addition, platinum-palladium alloy, chromium, silver, copper, aluminum, etc., are also available for sputtering.

   Besides, the double coating method (e.g., one thin coat of carbon topped by one coating of gold) is widely used for various specimens.

3.11 Troubles in Operation

Reconfirm operation in the following cases. If the troubles can not be remedied, refer to TROUBLE-SHOOTING.

1. Power can not be applied.
   - . Power of 100VAC, signal phase, 50/60 Hz is not supplied.
   - . The switch on the distribution board is OFF.
   - . DP has not returned to the reset temperature yet after power or water failure.

   Refer to [START/RESTART] .

2. The specimen chamber can not be evacuated or admitted air.
   - . Evacuation (EVAC)
     - . RP evacuation sounds does not go off. → Check O-rings, etc.
     - . The evacuation sequence [HT READY] on LCD goes out. → Has evacuation been conducted for 3 min after pressing the [EVAC] switch?
   - . Admitting air (VENT)
     - . Have 30 sec passed after pressing the [VENT] switch? (It takes about 30 sec to reach atmospheric pressure.)

3. Images do not appear.
   - . [HT] switch is not ON (LED goes out).
   - . [FILAMENT] control is set to a wrong position.
   - . Setting is other than [SET] . (in especially, MID, IMS.)
   - . The evacuation sequence [HT READY] on LCD is not indicated still. (Evacuation has not been completed.)
   - . The filament is burnt out.

   Refer to [OBSERVATION, PHOTOGRAPHY, FILAMENT REPLACEMENT] .

4. Images can not be focused.
   - . Astigmatism exists.
   - . Contrast and brightness are too low for the Automatic Focusing Device to work.
   - . Specimens are tilted at 60° or more.

   Refer to [OBSERVATION] .

5. Astigmatism can not be corrected.
   - . Contrast and brightness are too low for the Automatic Astigmatism Correction Device to work.
   - . Images are not focused.

   Refer to [ASTIGMATISM CORRECTION] .

6. Images can not be photographed properly.
   - . The exposure marker is not set in optimum.
   - . The dark slide of the camera (CSI) remains inside.
   - . The aperture value of the camera (CSI) is not proper.
   - . After photographing, the film has not been wound up.

   Refer to PHOTOGRAPHY .

7. After the filaments have been replaced and aligned, images do not appear.
   - . The evacuation sequence HT READY on LCD is not indicated still. (Evacuation has not been completed.)
   - . HT is not ON.
   - . Alignment is not sufficient.
   - . The filament is burnt out.

   Refer to FILAMENT REPLACEMENT, ALIGNMENT .

8. CPU resetting
   Resetting is required in the following cases.
   (The CPU resetting switch is provided near TV signal output terminal on the rear panel.)
   (1) The key input can not be carried out from the flat panel (Keypad).
   (2) The LCD indication goes out suddenly.
   (3) The others can not be operated.

3.12 How to Obtain High Quality Images and Photographs

Although this microscope is designed for easy operation for all the operators, the better image and photography can be obtained with attention to the following points (except in case under the specified conditions):

1. Prepare the specimen in the method suitable for specific specimen.
2. Set the tilt angle between 20° and 30°.
3. Select the accelerating voltage properly according to the specimen.
4. Change [SPOT SIZE] according to each specific purpose.
   . High resolution ..... 7 to 8 o'clock position
   . Large amount of signals .... 11 to 2 o'clock position
   . BEI·TV ..... 12 to 3 o'clock position
5. Adjust the focus in the viewing field for recording and correct astigmatism in as short a time as possible.
   Or, adjust the focus and correct astigmatism in the other viewing field.

CHAPTER 4 PRACTICAL USE OF SCANNING MICROSCOPE

CONTENTS

4.1 General Description of Scanning Electron Microscope 4-3
4.1.1 Comparison of Microscopes 4-3
4.1.2 Principle of Scanning Electron Microscope 4-4
4.1.3 Signals Obtained from Specimens 4-5
4.1.4 Composition of Scanning Microscope 4-7
4.1.5 Component Functions of Scanning Microscope 4-9

4.2 Selection of Accelerating Voltage (ACCELERATING VOLTAGE) 4-11

4.3 Effects of Electron Probe Diameter (SPOT SIZE) 4-13

4.4 Focusing and Astigmatism Correction (FOCUS • STIGMATOR) 4-14
4.4.1 How to Use Focusing Device (COARSE • FINE) 4-14
4.4.2 How to Use STIGMATOR (X • Y) 4-14
4.4.3 How to Use Automatic Focusing Device (AFD) and Automatic Astigmatism Correction Device (ASD) 4-15

4.5 Scanning System 4-16
4.5.1 Scanning Mode 4-16
4.5.2 Scanning Speed 4-16
4.5.3 TV Scanning 4-16
4.5.4 Automatic Magnification Corrector (MAC) 4-17
4.5.5 Viewing Field Fine Shift (IMAGE SHIFT) 4-18

4.6 Specimen Stage 4-19

4.7 Detector 4-21

4.8 Display System 4-22
4.8.1 Rapid Exposure Marker 4-22
4.8.2 Automatic Contrast & Brightness Control (ACB) 4-24

4.9 Camera for Scanning Image (CSI) 4-25
4.9.1 Camera for Scanning Image and Film 4-25
4.9.2 Types and Specifications of Cameras for Scanning Images 4-26
4.9.3 Component Parts of Camera for Scanning Image 4-27
4.9.4 Aperture Value Setup 4-32
4.9.5 Preparation of Camera for Scanning Image 4-33
4.10 Auto Data Recording 4-34
4.10.1 Film Number 4-35
4.10.2 Data Readout on Photograph 4-36
4.11 Photographing Time and Photo Time Monitor 4-37
4.12 Recording CRT (PRD1/UHR) 4-38
4.13 Evacuation System 4-39
4.13.1 Operation of Evacuation System 4-39
4.13.2 Evacuation Sequence Indication 4-40

CHAPTER 4 PRACTICAL USE OF SCANNING MICROSCOPE

4.1 General Description of Scanning Electron Microscope

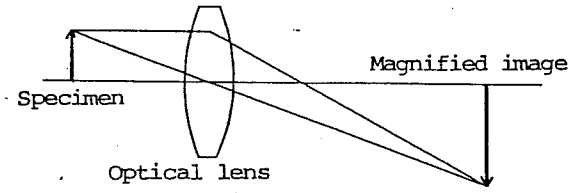
4.1.1 Comparison of Microscopes

	Optical microscope	Scanning electron microscope	Transmission electron microscope
Emission	Light	Electron beam	Electron beam
Medium	Atmosphere	Vacuum (below 10^{-4}Pa)	Vacuum (below 10^{-5}Pa)
Resolution	200 nm ∿	Approx. 4 nm ∿	Approx. 0.14 nm ∿
Contrast	Absorption/ reflection	Secondary electron effect	Scattering/ diffraction
Lens	Optical glass lens	Electromagnetic lens	Electromagnetic lens
Depth of focus	Shallow	Very deep	Deep
Magnification change method	Lens replacement	Scanning width	Excitation of magnifying lens system
Specimen thickness	Usually 0.5 μm min	Usually 10 mm max.	Usually 1 μm max.
Specimen preparation	Easy	Relatively easy	No easy

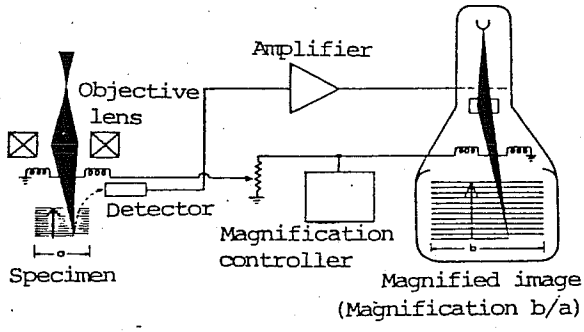
Table 4-1 Comparison of Microscopes

3 types of microscopes that have been propagated are scanning microscope (generally quoted as scanning electron microscope), optical microscope and transmission electron microscope (image-forming-lens type electron microscope). They have their respective advantages, limitations and drawbacks. Namely, optical microscope features (1) shallow focus depth and (2) insufficient resolution. On the other hand, transmission electron microscope can (3) only observe the specimen of very thin (usual thickness less than 1 μm = 10,000Å) transmitted image although its resolution is excellent and (4) it is not easy to prepare the specimen.
Contrarily, the scanning microscope developed as high resolution microscope on the basis of principles quite different from these 2 types of microscopes has settled down these 4 defects to ensure its excellent features.

4.1.2 Principle of Scanning Electron Microscope



(A) Optical Microscope



(B) Scanning Electron Microscope

Fig. 4-1 Principle

The principle of the scanning electron microscope is as shown in Fig. 4-1. A finely focused electron probe scans the specimen surface and the secondary and backscattered electrons, etc., are emitted from the specimen surface. These signals are then detected and are fed to a synchronously scanned CRT as an intensity modulating signal and thus displays a specimen image on the CRT screen. The CRT raster width divided by the electron probe scanning width determines the image magnification. Secondary and backscattered electron images can be observed in standard. (BEIS is optional attachment.) Additionally, several signals can also be obtained from specimens by incorporating the attachments.

4.1.3 Signals Obtained from Specimens

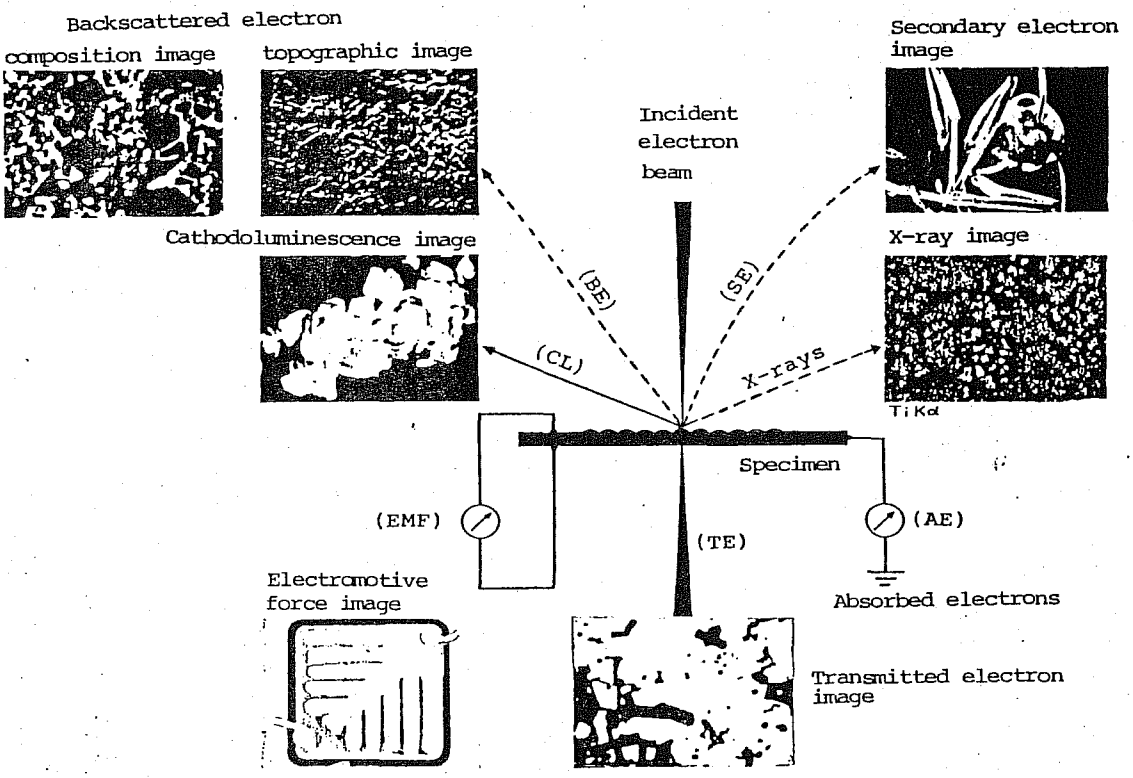


Fig. 4-2 Difference of Images with Signals

1. Secondary Electrons (SE)
   As the low-energy electrons are emitted from the vicinity of specimen surface, emission is different depending on the irregularity of specimen surface and the tilted angle.
2. Backscattered Electrons (BE)
   Electrons are backscattered by specimen and have almost the same energy as that of incident electrons.
   Comparing with secondary electrons, the backscattered electrons allow to obtain information from the inner parts of the specimen.
   Composition images and topographic images can also be obtained separately by using a special detecting method.
3. Transmitted Electrons (TE)
   Electrons transmitted through a thin specimen.
   Comparing with an electron microscope of image-forming-lens type, a scanning electron microscope excels in giving a transmitted electron image of (1) less chromatic aberration and (2) allowing contrast enhancement.

4. X-rays
   X-rays emitted from specimen can carry out elemental analysis.
5. Cathodoluminescence (CL)
   Cathodoluminescence means light emission from specimen atoms which have excited by the incident electrons. The cathodoluminescence image is effective for observing fluorescent specimens.
6. Absorbed Electrons (AE)
   The electrons absorbed by the specimen are detected as a specimen absorbed current.
7. Electromotive Force (EMF)
   Using a PN junction in the specimen as a detector, it detects the electromotive force corresponding to the photoconductive effect by photos.
   The electromotive force image is effective for observing semiconductor specimens.

4.1.4 Composition of Scanning Microscope

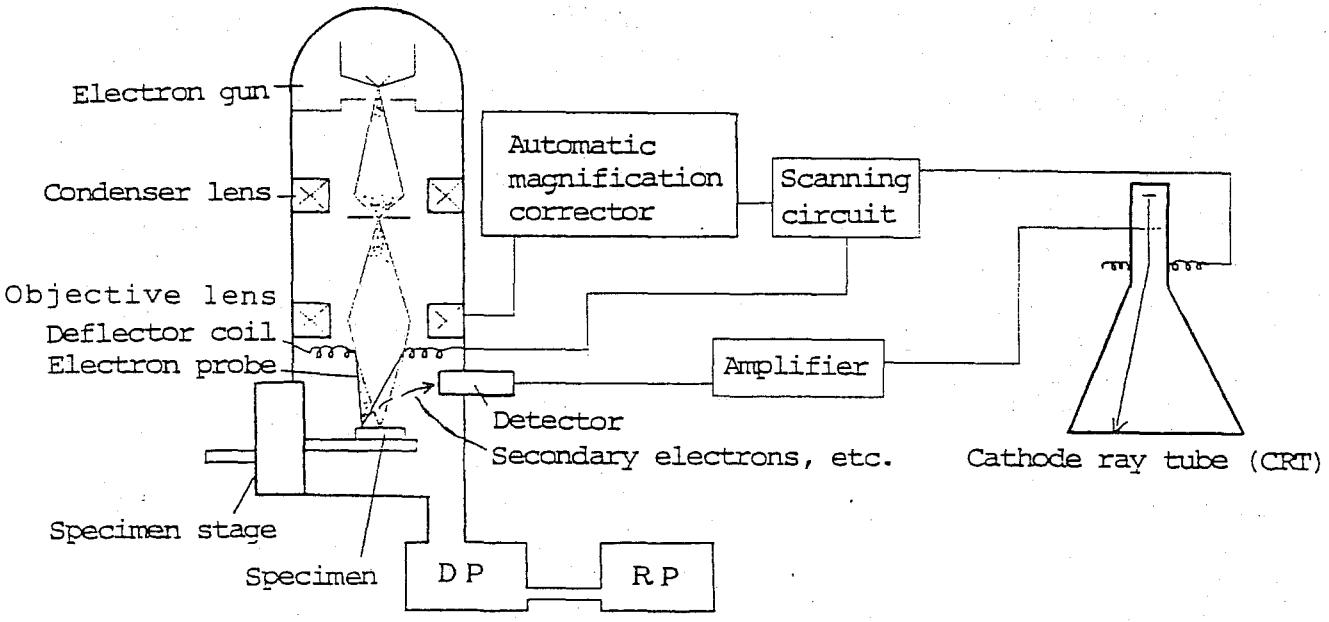


Fig. 4-3 Composition

Scanning microscope is composed of:

I Electron optical system
- (1) Electron gun as source of electron beam
- (2) Lens system to form electron fine probe
- (3) Astigmatism correction device that makes the fine formed electron beam (electron probe) in true roundness
- (4) Scanning system to control magnification

II Specimen stage
- (5) Specimen stage equipped with movement mechanism

III Display and recording system
- (6) Detector that detects the signal generated by interaction between electron probe and specimen, and amplifies the signal by converting it into an electric signal.
- (7) Display and recording system that displays and records (photography).

IV Vacuum system and checker
(8) Vacuum system to evacuate

Besides, this microscope builds inside (9) the automatic and manual checkers to check up the operation status. Consequently, the microscope can grasp the using conditions such as load current* of filament, condenser lens current and objective lens current, and its inspection and maintenance are very easy.

* This is load current to flow to the filament circuit as reference of filament heating current.

4.1.5 Component Functions of Scanning Microscope

I Electron Optical System

1. Electron Gun
   It is composed of Wehnelt and filament. Thermal electrons emitted from lead end of heated filament are concentrating and high voltage applied to anode accelerates the electrons to make electron beams.
2. Electromagnetic Lens System
   This system is composed of condenser lens and objective lens. These lenses reduce electron beams emitted from electron gun into electron probe in several nm ∿ several 10 nm and the electron probe is irradiated onto the surface of specimen.
3. Astigmatism Correction Device
   This device is composed of 2 sets of electromagnets each with a pair of 4 poles and corrects the electron probe into true roundness. Due to astigmatism, the focus position is generally different by lens system and specimen in direction where sections of the electron probe intersect directly. Therefore, if it is in defocus, image is blurred and even if it is in focus, the image is dull focused by larger diameter of probe. For solution, the electron probe is made to formed more finely by meeting the each focus in the intersecting direction so as to obtain very sharp image.
4. Scanning System
   This system is composed of deflector coil to scan over the surface of specimen by deflecting electron probe horizontally and vertically, and the scanning circuit. It controls magnification by changing the scanning width over the surface of specimen, and also controls the scanning speed.
5. Specimen Stage
   This stage is equipped with the mechanism to move the specimen placed in vacuum in high precision so as to allow the observation of each specific position of specimen.

II Detection and Display System

6. Detector

This detector is composed of secondary electron correction electrode (collector), scintillator and photomultiplier tube (PMT). The signal intensity of secondary electron and backscattered electron emitted for specimen are converted to intensity of light by scintillator, and then converted into electrical signals and amplified with PMT.

Optionally available are semi-conductor type backscattered electron detector, transmitted electron detector, X-ray detector, cathodo-luminescence detector, infrared cathodoluminescence detector and amplifier for electromotive force image.

7. Display and Recording System

This system is composed of control circuit for electrical signal from detector, CRT and camera. It displays on CRT screen the image obtained by signal from detector and photographs the image with camera for recording.

III Vacuum System and Checker

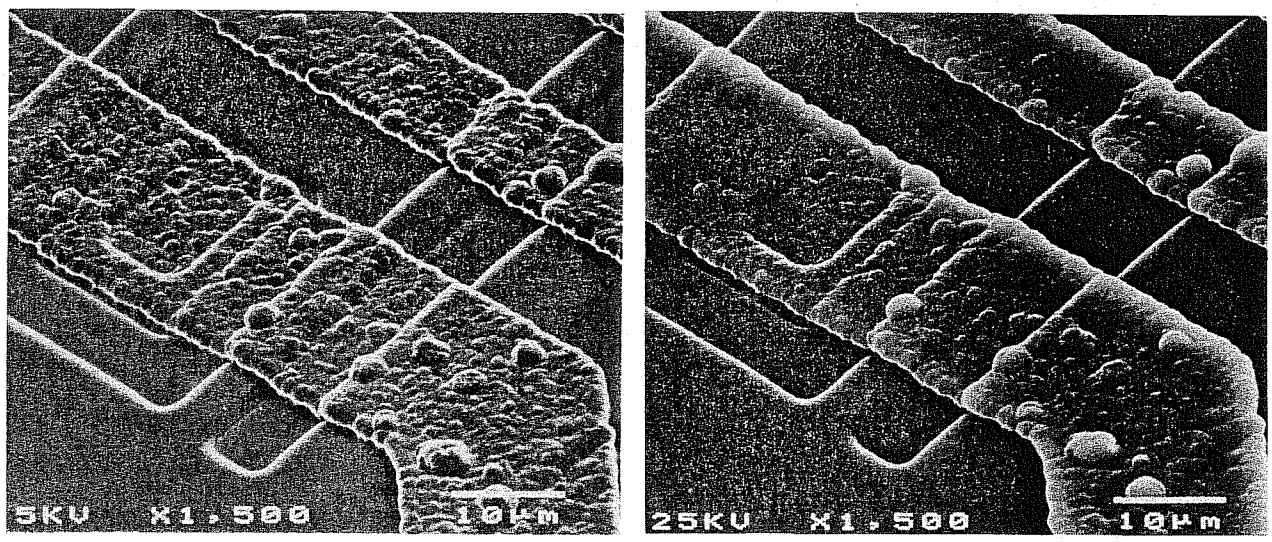
8. Vacuum Evacuation System

This system is composed of oil rotary pump (RP) for roughing, oil diffusion pump (DP) for high-vacuum evacuating and the circuit to control the vacuum sequence. It evacuates to keep electron gun and the inside of lens (in column) in high vacuum in order to avoid scattering of electron beams. Vacuum system is controlled auto-matically.

9. Checker

The checker is composed of auto checker for automatic checkup of 5 items and manual checker for manual checkup of 9 items.

4.2 Selection of Accelerating Voltage (ACCELERATING VOLTAGE)



Low accelerating voltage High accelerating voltage

Fig. 4-4 Difference of Images at Accelerating Voltages

Accelerating Voltage (KV)	(1, 2) (5, 10, 15, 20, 25)	Remarks
Resolution	→ High	
Specimen charge-up	Good ←	No coating or insufficient coating specimen
Effect of specimen contamination	Less ←	Biological or high-polymer specimens; excessive beam irradiation
Specimen damage	Less ←	
Image quality	Soft ↔ Hard	Edge effect makes edge brighter.
Signal in concavity	→ Rich	

Table 4-2 Effects of Accelerating Voltage
(Inside ▭ indicates an advantage.)

* Specimen charge-up : A part of screen grows specifically brighter by charge-up of electron.
Specimen contamination: Contamination of specimen makes image darker and/or edge becomes not sharp.

1. Most commonly used accelerating voltage is at 20 kV order, but it should be changed for special specimens and purposes.
   . Resolution
   Resolution is higher with higher accelerating voltage by the reasons that (1) electron gun is in higher brightness and (2) electron probe can be concentrated more finely.
   . Specimen Charge-up
   If accelerating voltage is higher, electrons penetrate to the specimen more deeply. This makes more electrons deposit in it and charge it up much more easily. Therefore, if the specimen is not coated or coated insufficiently, low accelerating voltage is preferable. Coat metal if high accelerating voltage is used.
   . Effect of Specimen Contamination
   Contamination of specimen is due to electron probe irradiation. Contamination is less at low accelerating voltages.
   . Specimen Damage
   High accelerating voltage damages the specimen easily. Accordingly, coat the metal as a rule if high accelerating voltage is used. If the specimen is not coated or insufficiently coated, low accelerating voltage should be selected.
   . Image Quality
   If the accelerating voltage is higher, signals from the edges of specimen are produced more due to the edge effect and this makes the image in higher contrast. Contrarily, if the accelerating voltage is lower, the image is softer as a whole with less edge effect. Moreover, generation of secondary electrons reaches to the peak at 1 kV order and this indicates that the optimum accelerating voltage is selectable dependently on the type of specimens.
   . Signal in Concavity
   Electrons penetrates more deeply into the specimen, if the accelerating voltage is higher and this increases signals in concavity.

4.3 Effects of Electron Probe Diameter (SPOT SIZE)

SPOT SIZE control	Turned counter-clockwise ⟵ Turned clockwise
Condenser lens current	[More] ⟵ [Less]
Electron probe diameter	[Small] ⟵
Resolution	[High] ⟵
Incident electron beam current	⟶ [More]
Specimen damage	[Less] ⟵
Secondary electron signal	⟶ [Rich]
Image quality	[Noisy] ⟵ ⟶ [Smooth]
Image selection	Secondary electron image (SEI) ⟵ ⟶ Backscattered electron image (BEI)

Table 4-3 Spot Size Effect (inside [ ] indicates an advantage.)

SPOT SIZE control is used to change excitation current of condenser lens and it has various effects as shown in Table 4-3, since incident electron beam current changes together with electron probe diameter.
It is chiefly used as below:

- High resolution : 7 o'clock to 9 o'clock
- Normal use position : 10 o'clock to 12 o'clock
- Rich signal use position : 12 o'clock to 2 o'clock
- Backscattered electron & TV mode : 12 o'clock to 3 o'clock

4.4 Focusing and Astigmatism Correction (FOCUS • STIGMATOR)

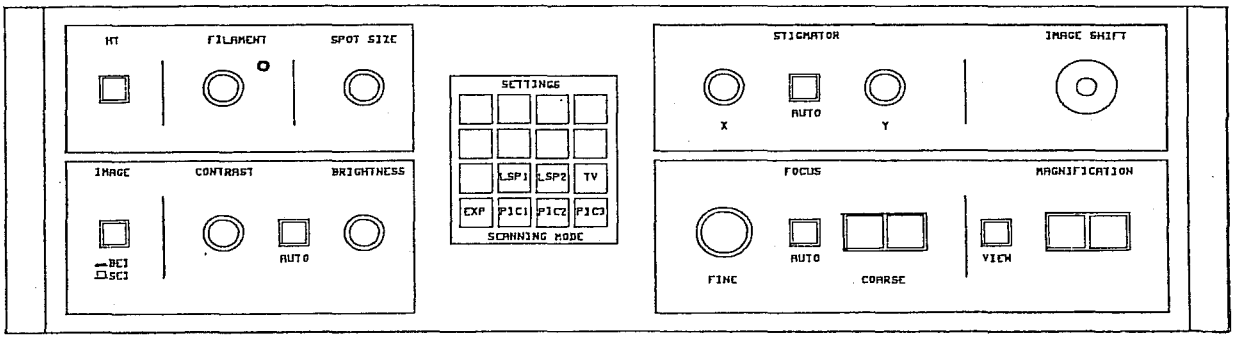


Fig. 4-5 Control Panel

4.4.1 How to Use Focusing Device (COARSE • FINE)

Focus by change objective lens current.

[COARSE] left-side switch	:	Objective lens current decreases at each pressing. Buzzer sounds at minimum current (MIN).
[COARSE] right-side switch	:	Objective lens current increases at each pressing. Buzzer sounds at maximum current (MAX).
[FINE] control	:	Objective lens current increases by turning this control clockwise.

4.4.2 How to Use STIGMATOR (X • Y)

Correct astigmatism with [X] and [Y] controls for manual operation.

4.4.3 How to Use Automatic Focusing Device (AFD) and Automatic Astigmatism Correction Device (ASD)

1. Automatic Focusing Device (AFD)
   Work by pressing the FOCUS [AUTO] start switch once.
2. Automatic Astigmatism Correction Device (ASD)
   Work by pressing the STIGMATOR [AUTO] start switch once.
3. Hard conditions for operating auto functions
   - Signals in specimen are not enough and image is not clearly seen.
     ——> Adjust the [SPOT SIZE] and the [CONTRAST] controls.
   - Structure of specimen is less.
     ——> Make viewing field with much structure.
   - Specimen is charged up and contrast is abnormal.
     ——> Adjust Accelerating voltage, the [SPOT SIZE] and the [CONTRAST] controls.

4.5 Scanning System

4.5.1 Scanning Mode

[LSP] : It scans on the line of specimen surface that passes at the center of image and it comes at upper on the CRT if the signal is more rich.
It is used for the observation of line wave form, the electron gun alignment and focusing.

[PIC] : It is usual mode for image observation. It has the [SLOW] and [TV] modes.

4.5.2 Scanning Speed

LSP		PIC					PHOTO	
LSP1	LSP2	EXP	PIC1	PIC2	PIC3	TV	NOR (>)	QUICK (>>)
50 ms	10 s	0.27 s	0.36 s	3 s	10 s	16.6ms (EIA)	90 s (50Hz)	36 s (50Hz)
						20.0ms (CCIR)	75 s (60Hz)	30 s (60Hz)

(unit: s = sec, ms = $\frac{1}{1,000}$ sec)

Table 4-4 Scanning Speed

4.5.3 TV Scanning

1. TV scanning is adjust at EIA type for V = 60 Hz (Japan/U.S.A. Standards) or CCIR type for V = 50 Hz.
   TV image signal can be output easily from TV output terminal.
   . Output terminal : BNC-R connector
   . Output impedance : 75 ohms
   . Output signal : Composite video signal, positive polarity, 1Vp-p, H = 15.75 kHz, V = 60 Hz (EIA), 50 Hz (CCIR)
2. Use of attachment together at TV mode
   At TV mode, following attachments can not be used.
   . BCX, BEIS, FKB, DFU, EMF, MCR, RRD, VCD
   . CLD/CLDIR, TED (usable if MID is not mounted together.)

4.5.4 Automatic Magnification Corrector (MAC)

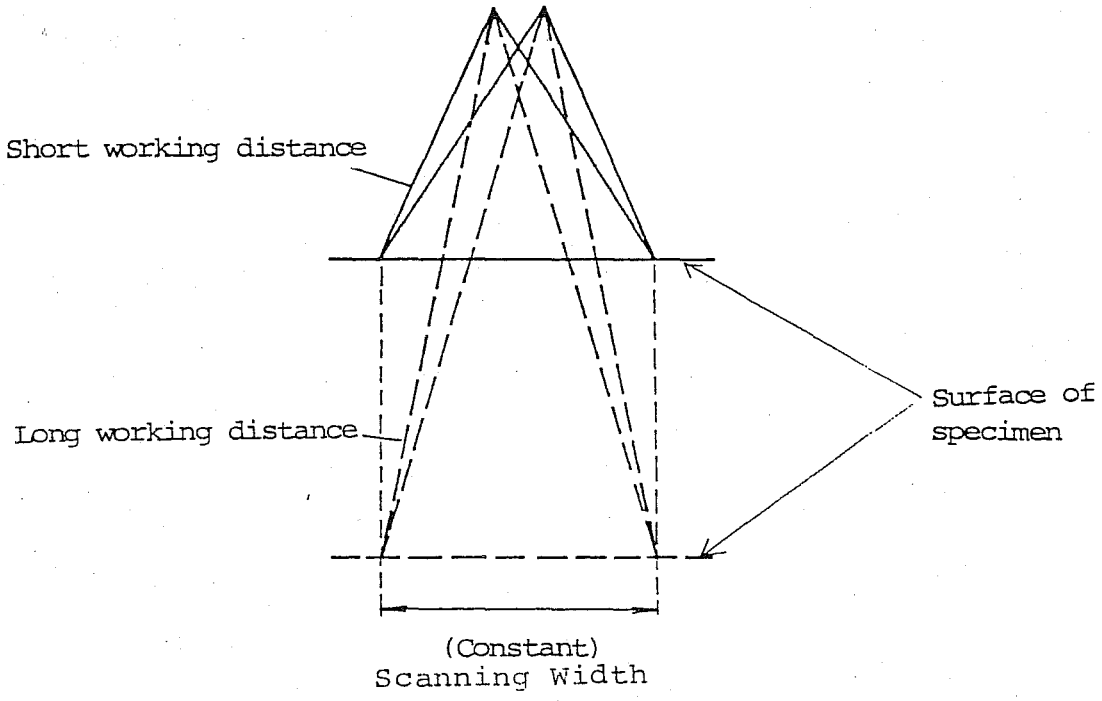


Fig. 4-6 Principle of MAC

It controls the deflector coil current to make magnification the same as indicated by means of objective lens current when setting the WD of the specimen.

1. The magnification is automatically corrected at the working distance of 10, 20 and 48 mm.
   Adjust the specimen height (specimen surface) to align it with the specimen holder top.

2. Magnification display may be uncorrectly due to the characteristic of objective lens if working distance is largely changed.

-	(15)	-	(35)	50	75
100	150	200	350	500	750
1,000	1,500	2,000	3,500	5,000	7,500
10,000	15,000	20,000	35,000	50,000	75,000
100,000	150,000	200,000	-	-	-

Table 4-5 Magnification Table

Note: Values of ( ) are different for each working distance

WD (mm)	Minimum Magnification
10	x 50
20	x 35
48	x 15

Table 4-6 WD and Min. Magnification

3. Magnification is just as specified (Table 4-5).
4. Minimum magnification are different for each working distance (Table 4-6).

4.5.5 Viewing Field Fine Shift (IMAGE SHIFT)

The image shift of maximum 10 μm (accelerating voltage 25 kV, working distance 20 mm) can be made in the direction that the joystick was pushed down.

4.6 Specimen Stage

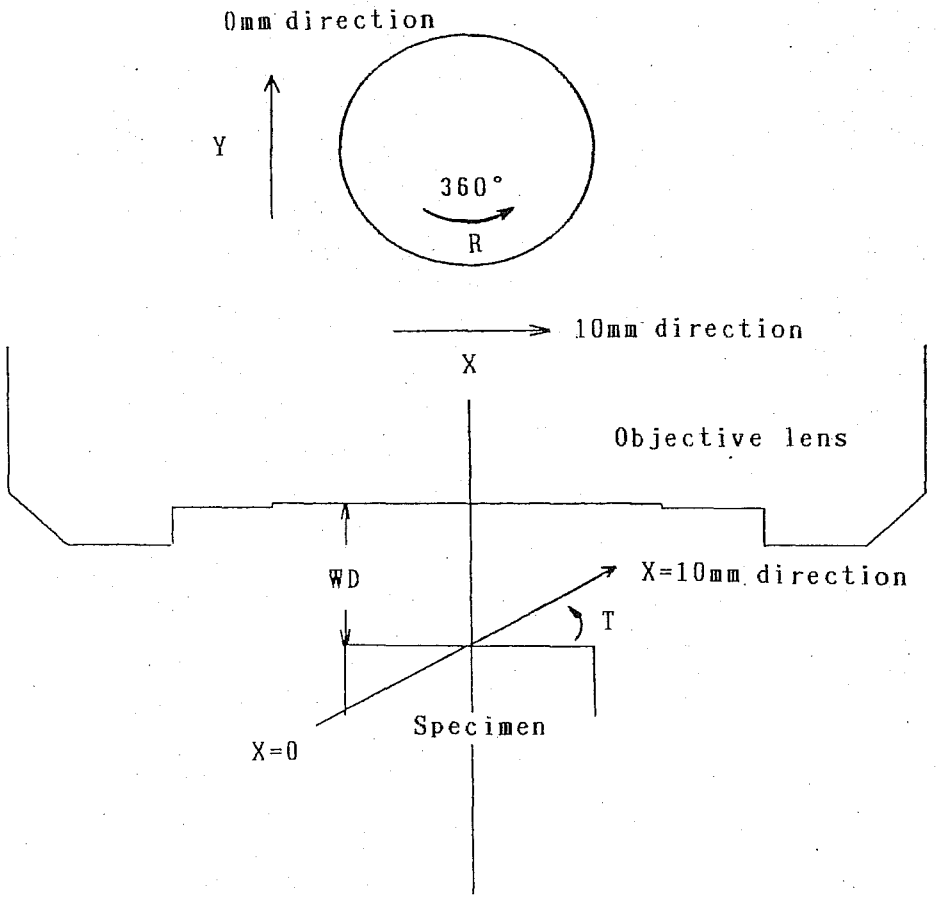


Fig. 4-7 Relation between Specimen Movement Direction and It's Tilt (as viewed from the front of specimen stage)

Specimen stage has X and Y controls for lateral movement of specimen, T (tilt) control for counterclockwise movement as seen from the front of specimen stage and R control for rotary direction of the specimen. Besides, Working Distance (WD) are variable 3 steps (10, 20, 48 mm).

Note, however, that the movement range of specimen is different depending on the size of specimen and attachments (only for mounting the specimen chamber).

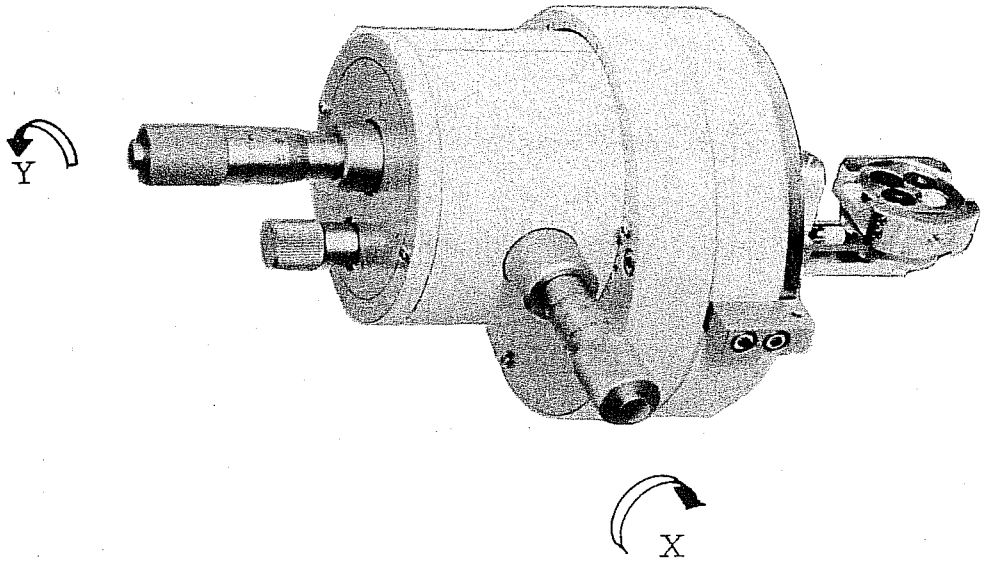
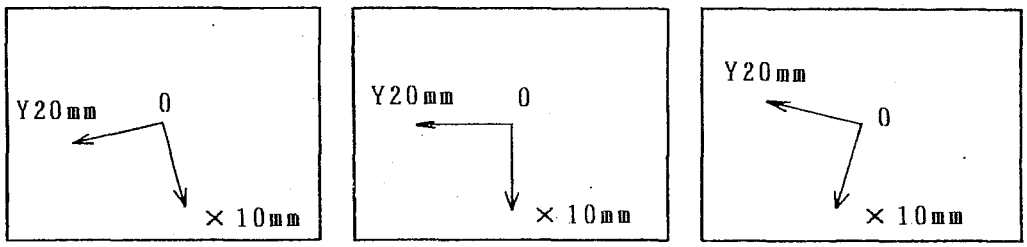


Fig. 4-8 Specimen Stage

In case of movement as illustrated above, the viewing field rotates depending on the working distance, and accordingly, each movement direction on CRT screen is also different as below.



WD 10 mm WD 20 mm WD 48 mm

Fig. 4-9 Specimen Stage (X·Y) and Movement of CRT Screen Image

4.7 Detector

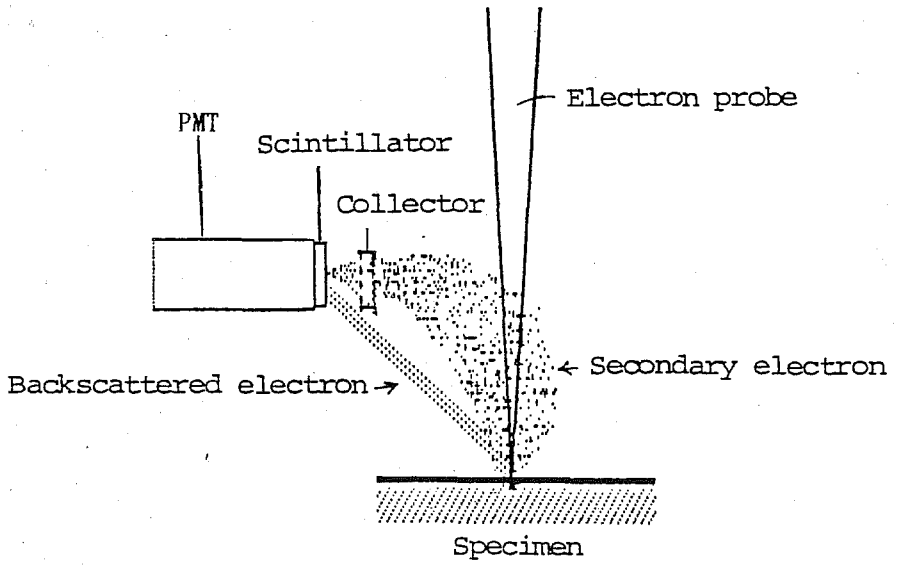


Fig. 4-10 Detection of Signals

In addition to secondary electrons, backscattered electrons are also detected slightly into the detector as usual and this obtains the backscattered electron image (backscattered electron image mixed up with topographic and composition images) with collector's voltage as negative potential.

. Selection of secondary electron image or backscattered electron image:
  IMAGE [SEI] : Secondary electron image

  IMAGE [BEI] : Backscattered electron image
. Sensitivity is low for observation of backscattered electron image. For solution, increase the incident electron beam current by turning [SPOT SIZE] control clockwise. Observe the backscattered electron image at 12 o'clock to 3 o'clock position.
  However, in the case of the backscattered electron detector (BEIS), comparing to the time of observing the secondary electron images, it is only necessary to turn the [SPOT SIZE] control knob slightly clockwise.
. The following detectors are supplied as optional.
  . Backscattered electron detector (BEIS)
  . Transmitted electron detector (TED)
  . Energy Dispersive X-ray Spectrometer (EDS)
  . Cathodoluminescence detector (CLD)
  . Infrared cathodoluminescence detector (CLDIR)
  . Electromotive force (EMF)

4.8 Display System

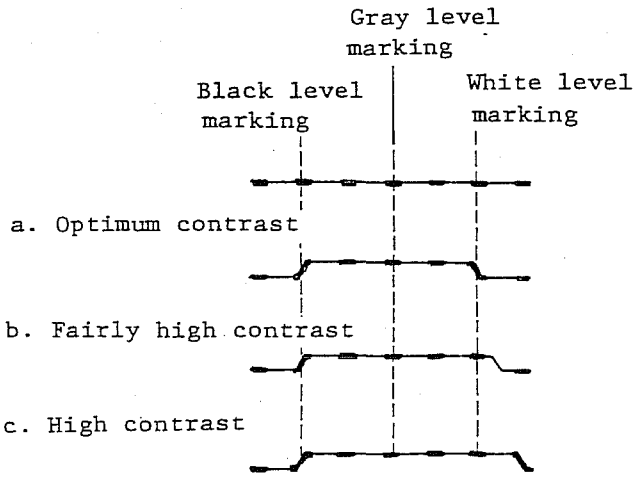


Fig. 4-11 Rapid Exposure Marker (I)

4.8.1 Rapid Exposure (CONTRAST & BRIGHTNESS)

Appropriate image quality is obtained by pressing the SCANNING MODE [EXP] key and setting the rapid exposure marker in optimum.
The exposure marker has been adjusted so that the appropriate exposure is obtained for photography when the lens aperture of Camera for Scanning Image (CSI) is set to 11 and ISO 75 film is used.
Furthermore, an even better photograph that satisfies the nature and condition of specimen or a photo with image quality you want can be obtained by employing the following procedure.

1. Higher Contrast Images
   Turn [CONTRAST] control clockwise to make contrast higher (brightness of the whole image is also increased). Then, adjust so that the rapid exposure marker width is made wider than the width of black level and white level marking.
   As the same time, always make the left edge of the exposure marker width align with the black level marking, by adjusting [BRIGHTNESS] control (image darkens when control turned counterclockwise).

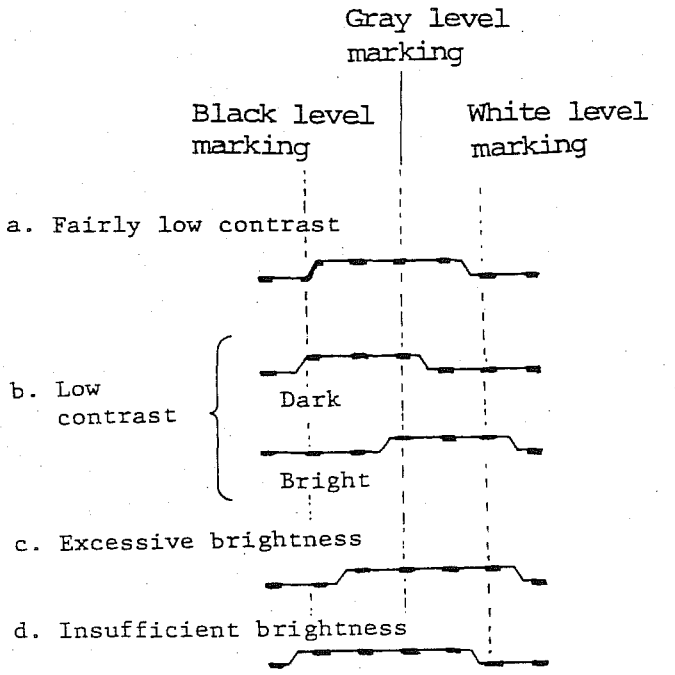


Fig. 4-12 Rapid Exposure Marker (II)

2. Lower Contrast Images
   Turn [CONTRAST] control counterclockwise to make lower contrast (brightness of the whole image is also decreased) and adjust so that the rapid exposure marker width is made narrower than the width of black level marking and white level marking.
3. Change of Photo Brightness
   To brighten : Turn [BRIGHTNESS] control clockwise.
   But, brightness is excessive if the center of exposure marker width is positioned at the right of gray level marking.
   To darken : Turn [BRIGHTNESS] control counterclockwise.
   But, brightness is insufficient if the center of exposure marker width is positioned at the left of gray level marking.

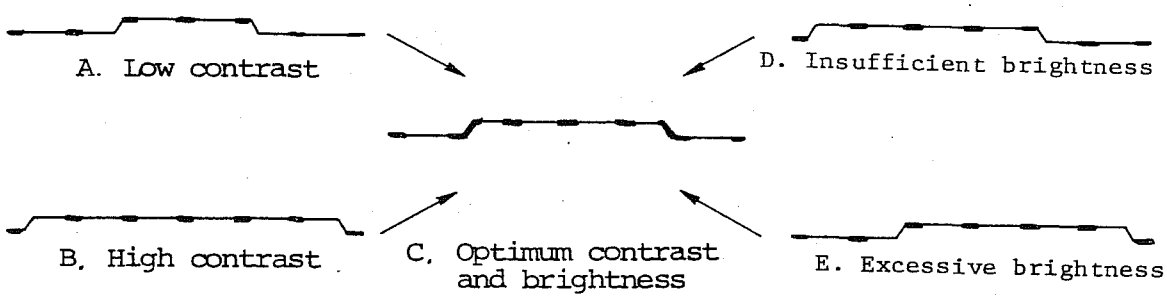


Fig. 4-13 Rapid Exposure Marker (III)

4.8.2 Automatic Contrast & Brightness Control (ACB)

By pressing the ACB [AUTO] start switch, Automatic Contrast & Brightness Control (ACB) can maintain the optimum contrast and brightness if the contrast and brightness is kept by exposure marker within the range as illustrated in Fig. 4-13, even if brightness and magnification change. Also, the ACB operation reference value can be changed optionally by setting the ACB from the [EXP] mode.

4.9 Camera for Scanning Image (CSI)

4.9.1 Camera for Scanning Image and Film

The various cameras for scanning image to meet with each specific film are available so as to eliminate the need for focusing job when you change the film size.

Type (holder)	Photographing ratio to CRT	Available film and number of exposure
CSI1 (50A-MRH) Fig. 4-14	0.5	Brownie roll film: J 120, ISO 50, 100, 200, etc. (negative); 10 exposures per roll
		Brownie roll film: J 220, ISO 100, 400, etc. (negative); 20 exposures per roll
CIS2 (T20-PPH) Fig. 4-15	0.75	Polaroid Land pack film: type 105 or 665, ISO 75 (positive/negative); 8 sheets per pack
		Polaroid Land pack film: (positive) Type 611 (No coating type) ISO 200 Type 107 (ultrahigh speed) ISO 3,000 type 667 (No coating type) ISO 3,000 8 sheets per pack
CIS3 Fig. 4-16	0.25	35mm roll film: J 135, ISO 50, 100, 200, 400 etc. (negative); 12, 20, 24 or 36 exposures per roll
CSI5 (50A-PRH) Fig. 4-17a	1.0	Polaroid Land sheet film: Type 51 (high contrast) ISO 200 Type 52 (wide latitude) ISO 400 Type 55 (positive/negative) ISO 50 Type 57 (ultrahigh speed) ISO 3,000 20 sheets per pack
CSI5 (SM-PRH1) Fig. 4-17b	1.0	Polaroid Land pack film: (positive) Type 552 (wide latitude) ISO 400 Type 553 (No coating type) ISO 800
CSI6 Fig. 4-18	0.85	Polaroid auto film: (positive) Type 331 (high speed) ISO 400 10 sheets per pack

Table 4-7 Relation between CSI and Film

50A-MRH : Mamiya Roll Film Holder (Type 2, 6 × 7)
T20-PPH : Polaroid Pack Film Holder (CB-103)
50A-PRH : Polaroid Sheet Film Holder #545
SM-PRH1 : Polaroid Pack Film Holder 4 × 5

4.9.2 Types and Specifications of Camera for Scanning Image

Type	Lens	Aperture	Shutter	Reduction ratio	Optional holder	Others
CSI1	F=4.5, f=75mm	4.5 to 22	Manu & Auto	0.5	50A-MRH	
CSI2	F=4.5, f=75mm	4.5 to 22	Manu & Auto	0.75	T20-PPH	
CSI3	F=3.5, f=55mm	3.5 to 22	Manu & Auto	0.25		PSC
CSI5	F=4.5, f=75mm	4.5 to 22	Manu & Auto	1.0	50A-PRH, SM-PRH1	
CSI6	F=4.5, f=75mm	4.5 to 22	Manu & Auto	0.85		Power ON/OFF

Table 4-8 Specifications of CSI

PSC : AC adapter for CSI3
CSI6 : Power supply switch is provided at the back of camera in addition to manual and automatic shutters.
F : Indicates brightness of lens, or ratio between focus distance f and lens diameter.

Automatic shutter : This shutter controls scanning and exposes one frame only and it can perform data ON/OFF.
Manual shutter : Shutter opens/closes at each pressing of this shutter irrespective of scanning. The manual shutter should be closed as usual, and when it opens, the LED of SHUTTER on the display panel lights up.

4.9.3 Component Parts of Camera for Scanning Image

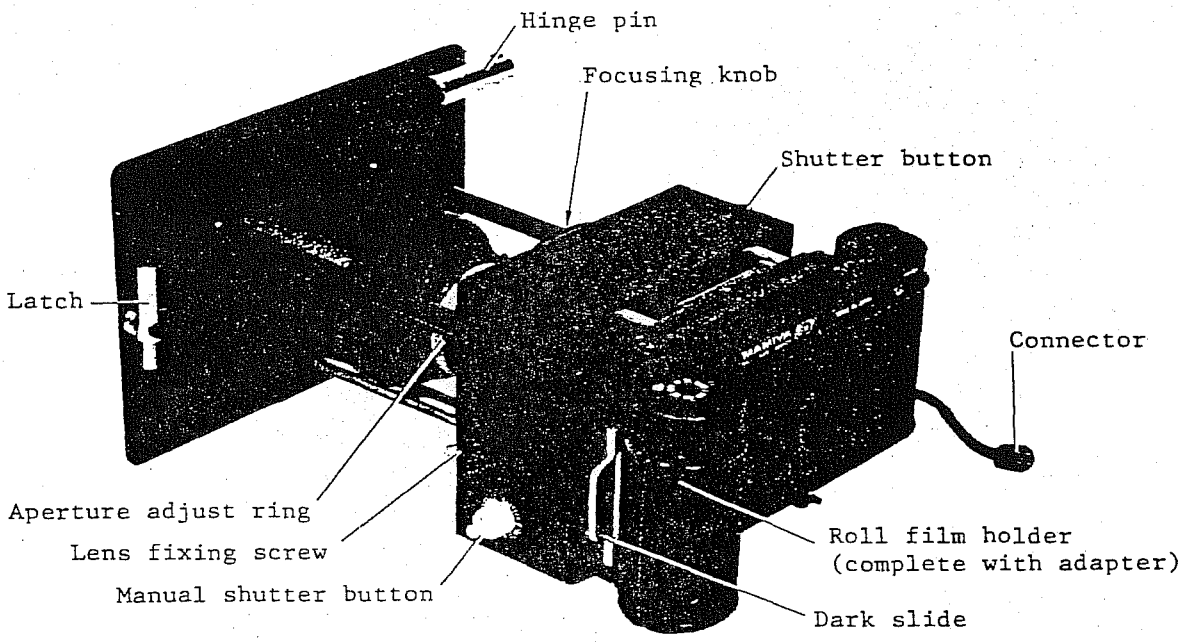


Fig. 4-14 CSI1

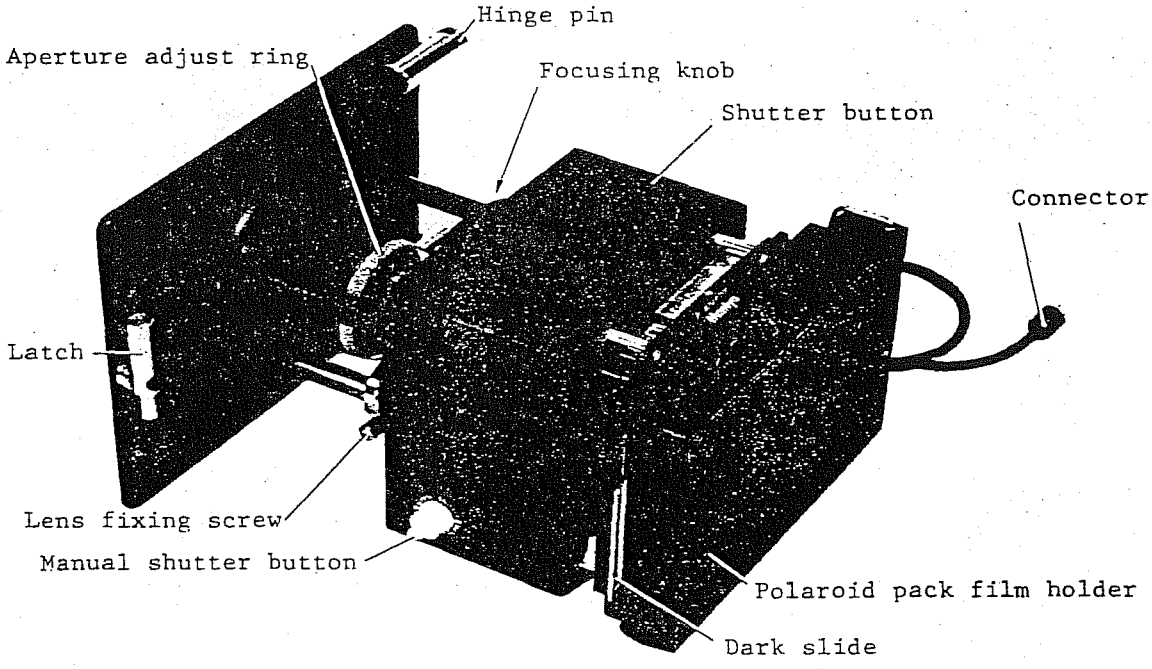


Fig. 4-15 CSI2

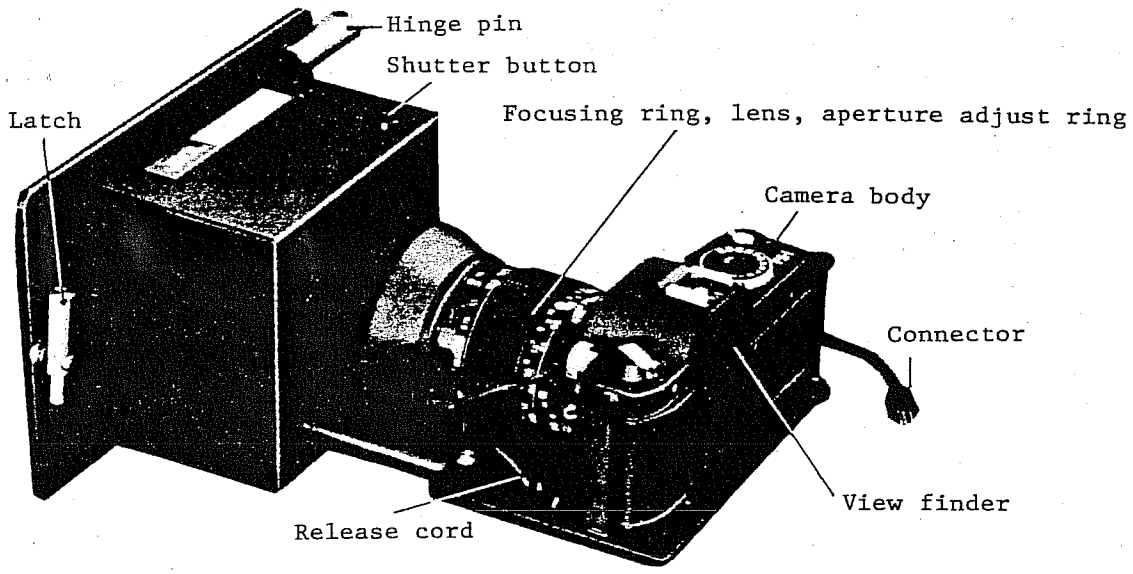
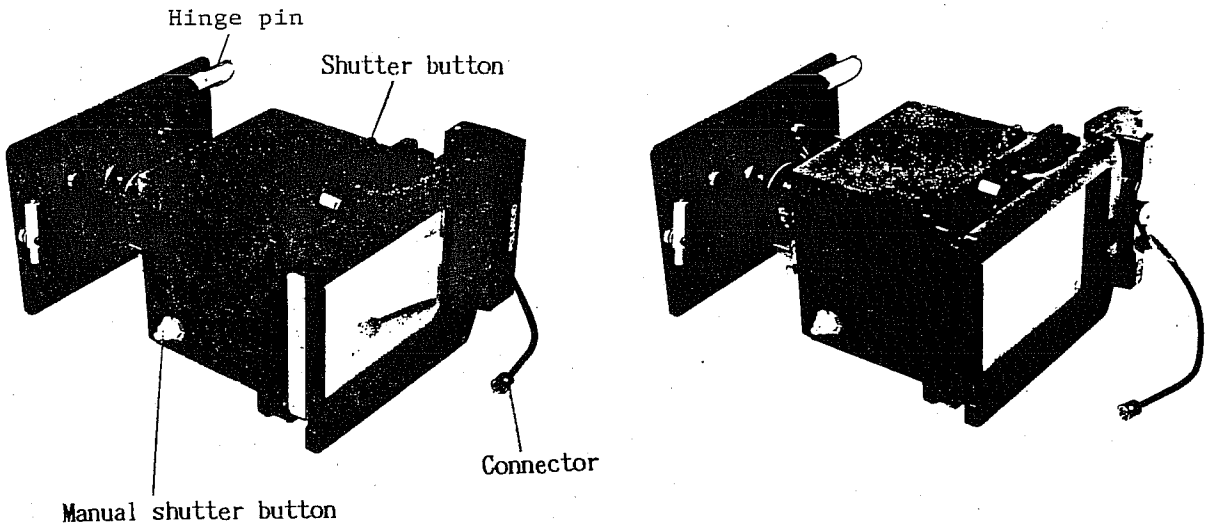


Fig. 4-16 CSI3



Polaroid #550
pack film holder

Polaroid #545
sheet film holder

Fig. 4-17 CSI5

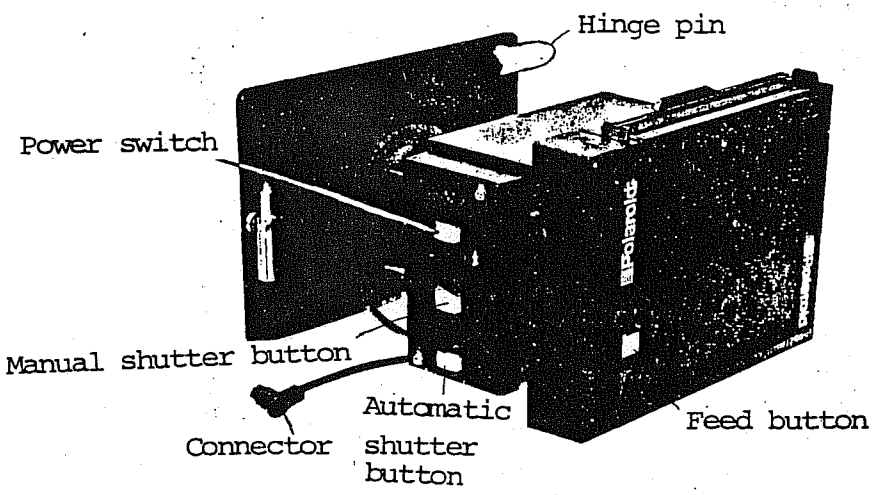

Hinge pin
Power switch
Manual shutter button
Automatic shutter button
Connector
Feed button
Polaroid

Fig. 4-18 CSI6

CSI5 Mounting

1. Focusing Glass

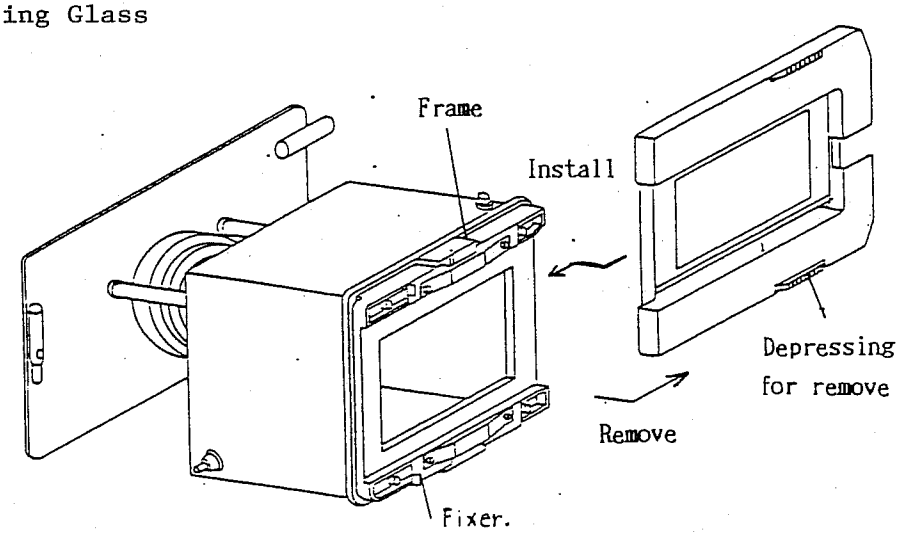


Fig. 4-19 Focusing Glass Mounting

Note: Frame should be slided for mounting 50A-PRH (#545) film holder. Refer to item 3 50A-PRH for further details.

2. SM-PRH1 (#550) Film Holder

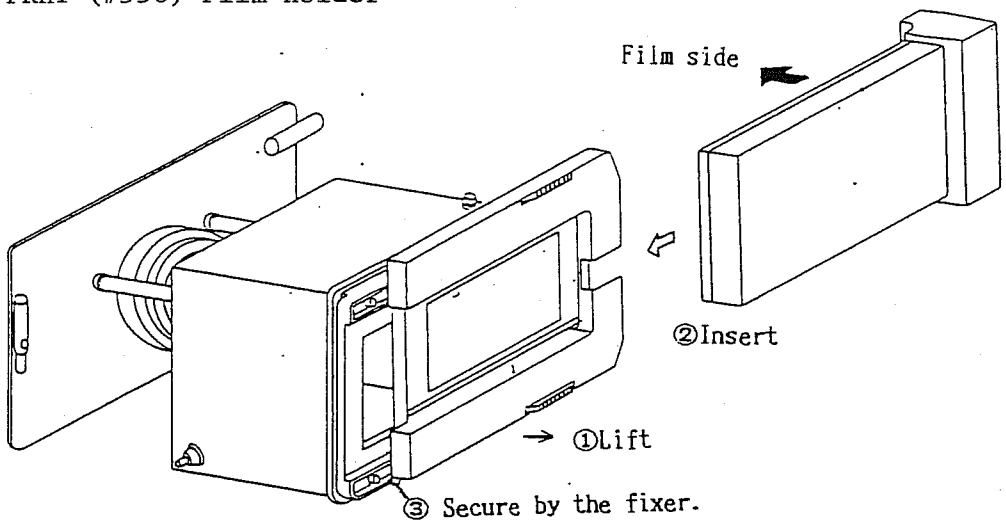


Fig. 4-20 Film Holder Mounting (SM-PRH1)

Note: Focusing glass can be removed if SM-PRH1 is fixed by the fixers.

3. 50A-PRH (#545) Film Holder
   a. Remove focusing glass, slide the frame fully to the left end and fix it.
   b. Install 50A-PRH same as SM-PRH1.

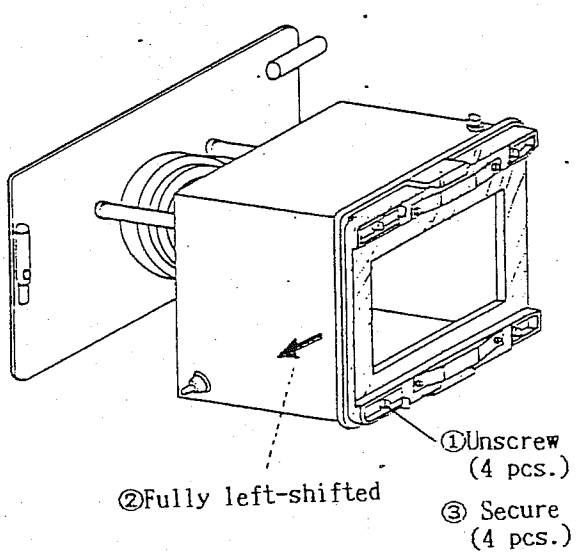


Fig. 4-21 Film Holder Mounting (50A-PRH)

Note: Mount the film holder after sliding the frame fully to the right end for replacing 50A-PRH with SM-PRH1.
Shift of frame: Approx. 3 mm

4.9.4 Aperture Value Setup

Film Sensitivity		Recording CRT-PRD, ultra-high resolution CRT-UHR; (NOR mode) Aperture value (CSI3)	Ultrahigh resolution CRT-UHR; (UHR mode) Aperture value (CSI3)
ISO	DIN		
50	18	f8 (f11)	——
75 ∿ 100	20 ∿ 21	f11 (f16)	——
200	24	f16 (f22)	——
400	27	f22 (——)	f8 (f11): Develop in 4× sensitivity
3,000	36	f22 with ND4 filter	f11 (f16)

Fig. 4-9 Relation between Film Sensitivity and CSI Aperture

ND4 filter: This filter reduces quantity of light to 1/4. Purchased filter in 52 mm dia. is available.

- Set up aperture value of CSI so as to meet the film (exposure marker standard).
- Ultrahigh resolution CRT-UHR has 2 modes:
  NOR mode; films with sensitivity up to ISO 400 (the resolution is a little lower than the cases at UHR mode).
  UHR mode; ultrahigh resolution recording mode
- Use of ultrahigh speed Polaroid film
  For recording CRT and ultrahigh resolution CRT-UHR (NOR mode), use usually polaroid films, type 105, 665, 52 and 55.

Note: Types 107 and 57 are high speed type corresponding to ISO 3,000. Their film particle is rough in narrow latitude and resolution is low as compared with types 105, 665, 52 and 55. Accordingly, use of film types 105, 665, 52 and 55 is recommended, since it is difficult to take good photograph with film types 107 and 57.

To use high speed film types 107 or 57, keep the following points in mind:

1. Fix the purchased screwing type filter in ND4 diameter 52 mm to the front side of CSI lens (this filter is not attached to the CSI as standard it should be ordered additionally.)
2. Set the aperture to f22.
3. Adjust contrast a little lower with the rapid exposure marker to take photograph.

4.9.5 Preparation of Camera for Scanning Image

Each type of CSIs can be handled almost in the same method. Refer to item 3.5 Photography for details of photographing. CSIs have been preadjusted at the shipment from the factory and therefore specific adjustment is not particularly required.

1. Insert the hinge pin of CSI into the mounting pin at the front side of display panel CRT and the connector into the socket of the display panel, aligning the white match-marks.
   (Perform this operation after turning OFF the power supply.)
2. Face CSI to CRT screen and fix it by latch.
3. Push the manual shutter button on the left side of CSI to open the shutter.
   Note: In case of CSI3, disconnect connector at the front of camera body, press the shutter button and look into the view finder. (Shutter speed should be at B.)
4. Set the lens aperture to 4.5 or 3.5 (open).
5. Attach a focusing glass into the port on film holder (not needed for CSI3).
   For CSI2, open rear cover of film holder and load the pack with focusing glass.
   For CSI6, open the cover at the back of CSI and load the pack with focusing glass.
6. Depress SCANNING MODE [LSP1] and [SHUTTER] on the display panel.
7. Adjust the focusing knob so that the scanning line of image on CRT can be clearly seen.
   Then, tighten the lens fixing screw while observing through the focusing glass with the loupe provided.
   For CSI3, adjust the focus by looking into view finder.
8. Insert the dark slide properly into the film holder prior to loading the film (not necessary for CSI3).
9. Remove the focusing glass, and attach the film holder containing the film.
   For CSI2 and CSI6, take out the pack.
10. Push the manual shutter button once again to close the shutter.
11. Turn the lens aperture adjust ring and set the aperture value according to the film speed in use.
12. For CSI3, set the shutter speed to B.
    Note: Connect the connector at the front of camera body.
    Connect the power connector to the camera body to use PSC.
13. For CSI6, turn ON power switch.

4.10 Auto Data Recording

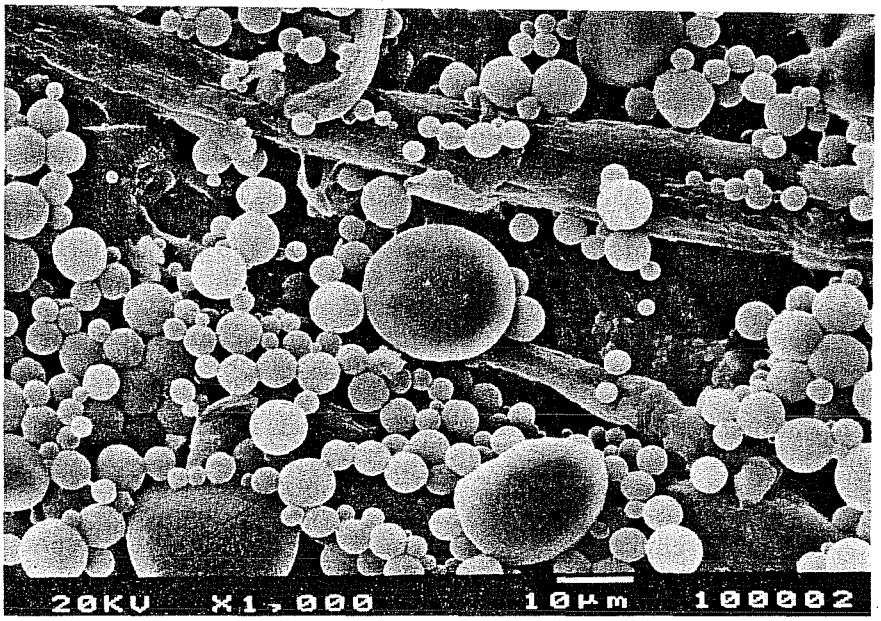


Fig. 4-22 Photo Data

The data displayed in SLOW mode is also recorded on the film when photographing. (It's lowest line and micron marker above the line.)
Every time the SETTINGS [FILM DATA] key is pressed, the film data printed mode will change sequentially as shown below.
The background of the data display on the CRT and photo are 「Image」

[FILM DATA] key ON → 「BLANK」 [FILM DATA] key ON → 「Data display OFF」

[FILM DATA] key ON → 「Image」

Notes:
1. The characters displayed with the Full Key Board (FKB: option) are also recorded on the film when photographing.
2. Both data and characters are not displayed in the modes other than the SCANNING MODE [PIC1] .

4.10.1 Film Number

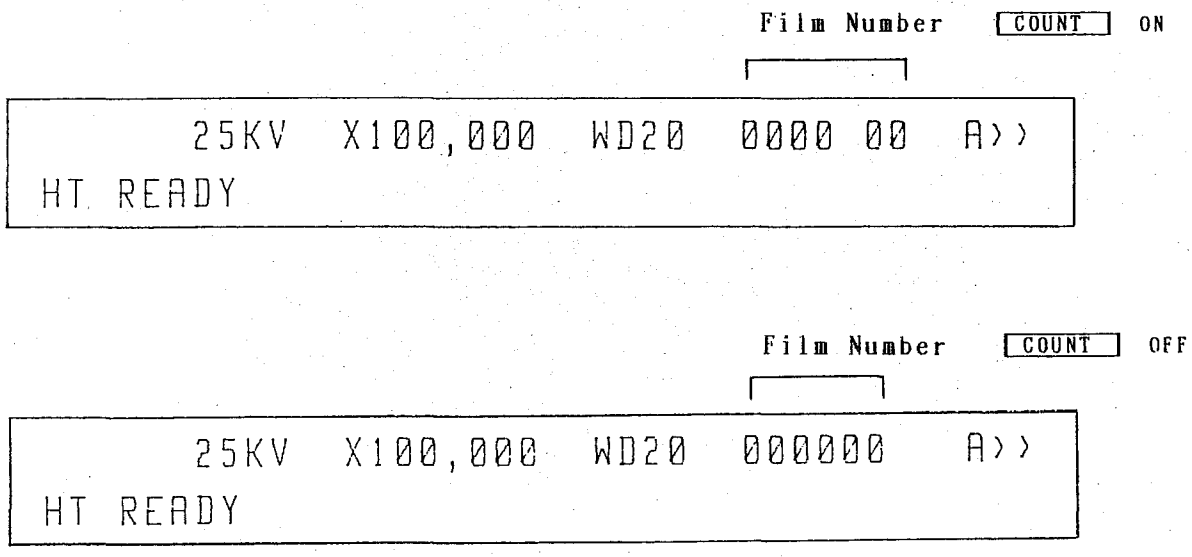


Fig. 4-23 Film Number

Film number is displayed on the LCD and the CRT screen in 6 digits. The lower 2 digits of the number are automatically or manually counted. Set with the number key after pressing the SETTINGS [SET] [FILM DATA] key. (They can be used for year, month, day, classification number, etc. Refer to 3.4.5 for details such as the input procedure and automatic count.)

A. Manual setting of 6 digits (any desired number)
   (1) Turn the [COUNT] switch on the display panel to OFF.
   (2) Set a desired 6 digits figures with the flat panel figure keys. Then, the preset figures become film number.

B. Automatic count of lower 2 digits from any desired figures.
   (1) Turn the [COUNT] switch on the display panel to ON.
   (2) Set the lower 2 digits to the figures to be counted up with the flat panel figure keys.
   (There are two kinds of automatic count: count up and count down. Refer to 3.4.5 (V).)

4.10.2 Data Readout on Photograph

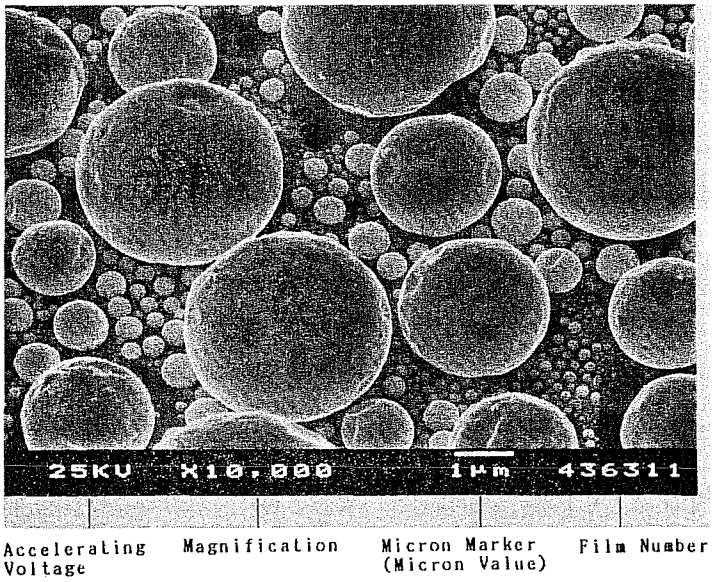


Fig. 4-24 Photo Data

1. Accelerating Voltage
   1 to 2 digits
   Example: 1 kV ... 1 kV, 25 kV ... 25 kV
2. Magnification (image magnification on CRT = displayed magnification for observation)
   Magnification of photograph is obtained by multipling the recorded magnification with photographing ratio.
   Example: The image magnification of photograph taken by CSI1 and observed in 10,000× is calculated by the following equation:
   (10,000×) × 0.5 = 5,000 ... 5,000×
3. Micron Value
   1 to 4 digits in D size display
   Example: 0.1 μm ... D = 0.1 μm, 1 μm ... D = 1 μm,
   1,000 μm ... D = 1,000 μm
4. Film Number
   6 digits and lower 2 digits of the number can be automatically counted up.

. Calculation of Magnification
  To find the image magnification of photograph, regardless of its size, measure the length D on the photograph and calculate it according to the following equation:

$$\text{Magnification} = \frac{\text{Measured value of D (mm)}}{\text{Value of micron marker}} ,$$

$$\text{Example: } \frac{25 \text{ mm}}{100 \text{ μm}} = \frac{25 \text{ mm}}{0.1 \text{ mm}} = 250\times .$$

4.11 Photographing Time and Photo Time Monitor

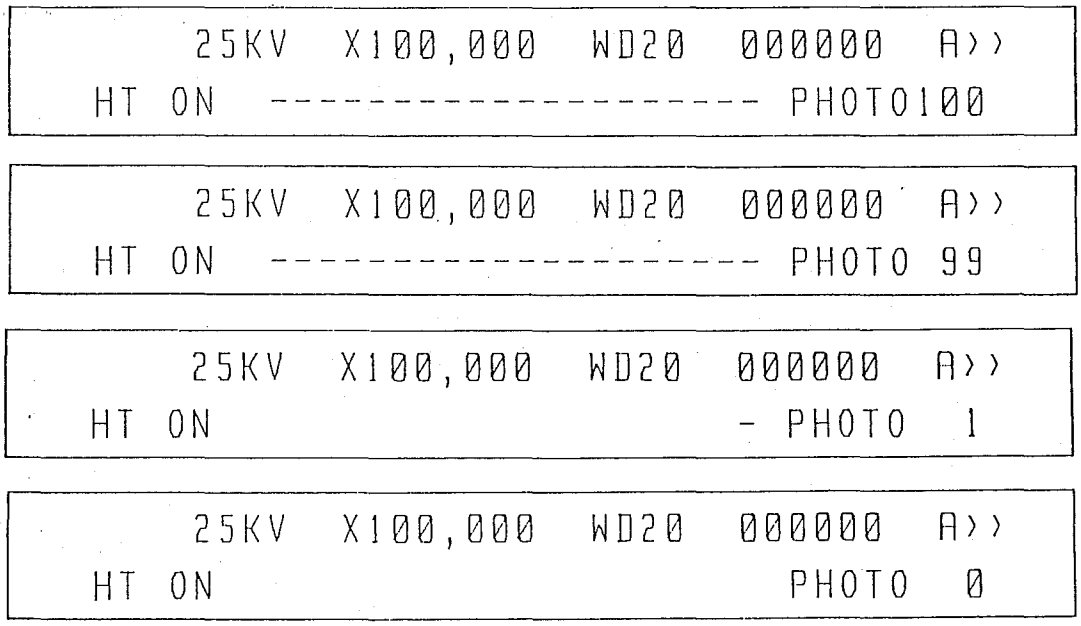


Fig. 4-25 Photo Time Monitor

1. Photographing time
   Press the [PHOTO SPEED] switch on the Display panel and select speed.

   For normal photographing: 90 sec (50Hz)/70 sec (60Hz) .. LCD indication >

   For quick photographing: 36 sec (50Hz)/30 sec (60Hz) .. LCD indication >>

   Note: If pressing the SHUTTER when "A" is indicated on LCD (A> or A>>), ACB works before photographing even in SLOW-scan mode. ACB always works before photographing from TV mode regardless of "A" indication on LCD.

2. Photo time monitor
   With the [SHUTTER] ON, the indicated figures for the photo time gradually decreases from 100 to 0. (The bar gradually goes out.) Now, photographing is completed and the LCD indication returns to original. The indicated figures of the photo time does not indicate seconds, but simply the photographing time divided by 100.
   Note: The [SHUTTER] LED lights up when exposure is performed using the manual shutter.

4.12 Recording CRT (PRD1/UHR)

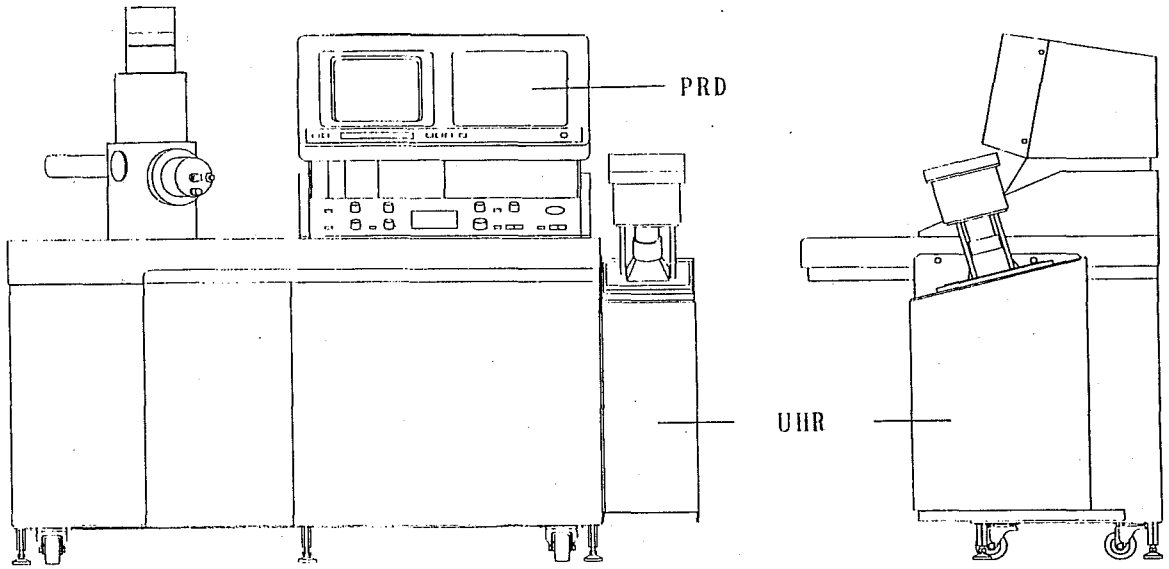


Fig. 4-26 Installation of Recording CRT (PRD1/UHR)

Recording CRT (PRD1) is mounted in the control console of microscope. Ultrahigh resolution CRT (UHR) is mounted at the right side of the control console.
The following components are provided on the UHR panel:

1 [CAMERA] : Camera connector to connect the cable from CSI

2 [BRIGHTNESS] : Brightness adjust control

3 [MODE] : NOR/UHR select switch

[UHR] mode; For using ultrahigh speed film at ultrahigh resolution mode. (ISO 400; develop in 4× sensitivity or ISO 3,000)

[NOR] mode; For using normal speed film at UHR (ISO 75 to 400).

4.13 Evacuation System

4.13.1 Operation of Evacuation System

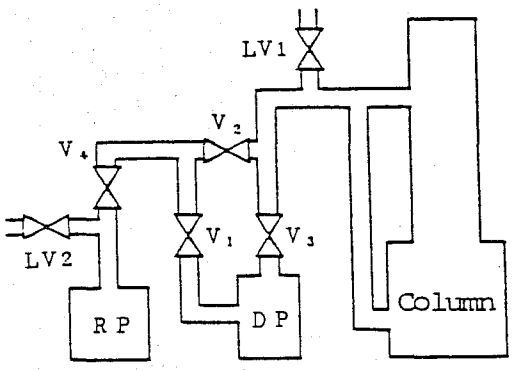


Fig. 4-27 Evacuation System

Normal evacuation is performed automatically in accordance with sequence control just by switch operation of [VENT] and [EVAC].

Operational Conditions	Value Status					
	V1	V2	V3	LV1	V4	LV2
POWER ON	o/×	o/×	×	o/×	×	×
(DP BACKING)	o	×	×	×	o	×
VENT	o	×	×	o	o	×
(PRE EVAC)	×	o	×	×	o	×
EVAC	o	×	o	×	o	×
POWER OFF (RP VENT)	o/×	o/×	×	o/×	×	o

o: Open ×: Close o/×: Alternative

Table 4-10 Evacuation Valve Status

4.13.2 Evacuation Sequence Indication

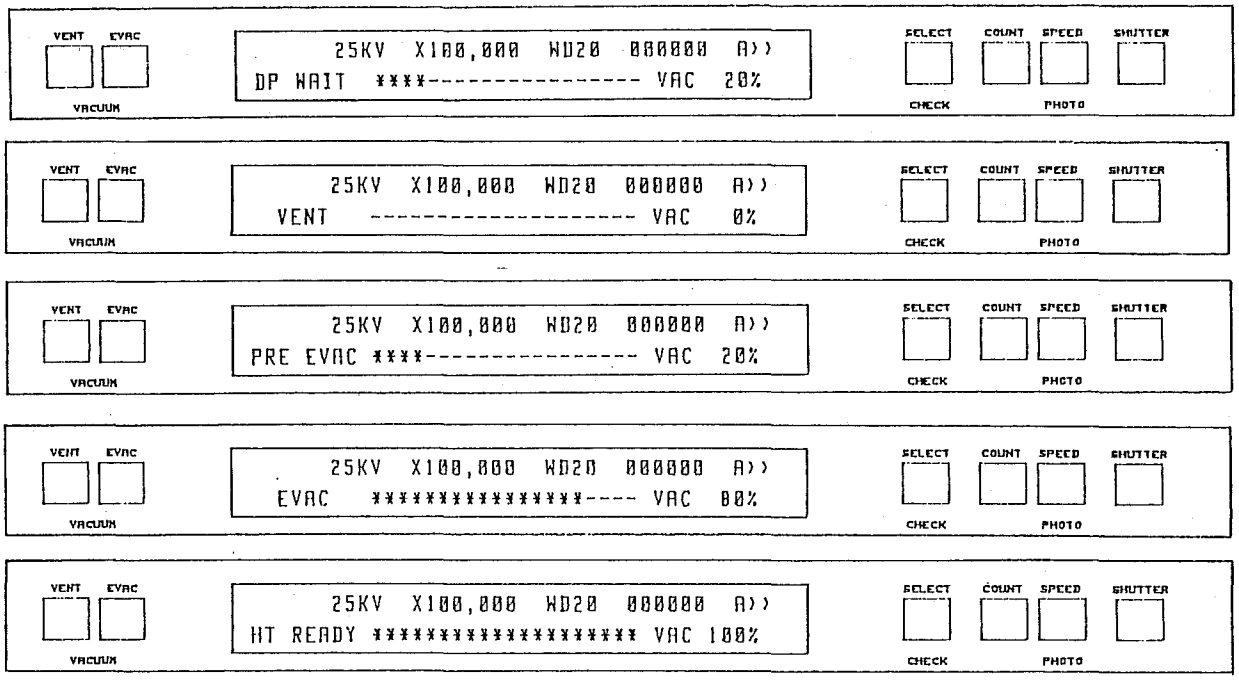


Fig. 4-28 Display Panel

Processing direction of evacuation sequence at start-up
: Indication on Liquid Crystal Display (LCD)

DP WAIT : At start-up, oil heating preparation (approx. 20 min.) of oil diffusion pump (DP)
VENT : Indicated when the [VENT] switch is pressed. The state of the atmospheric pressure (leak) in the microscope is shown.
PRE EVAC : Microscope column in pre-evacuation
EVAC : Microscope column in evacuation
HT READY : High Tension (Accelerating Voltage) application preparation is completed.
HT ON : High Tension (Accelerating Voltage) application state ([HT] switch ON).

Notes:
- "DP WAIT" is indicated only start-up and is not indicated during normal evacuation after DP oil has been heated.
- "VENT" is indicated at VENT regardless of the process of venting the column.
  [VENT] switch : Vents the column (leaks). Don't press the [VENT] switch when the specimen is heated and cooled.
  [EVAC] switch : Evacuates the column.
- "ALC" is indicated when the airlock device (option) is used.

INSTRUCTIONS

JSM-5200

SCANNING MICROSCOPE
(MAINTENANCE)

JEOL

No. ISM5200-1BE
(MP152001)

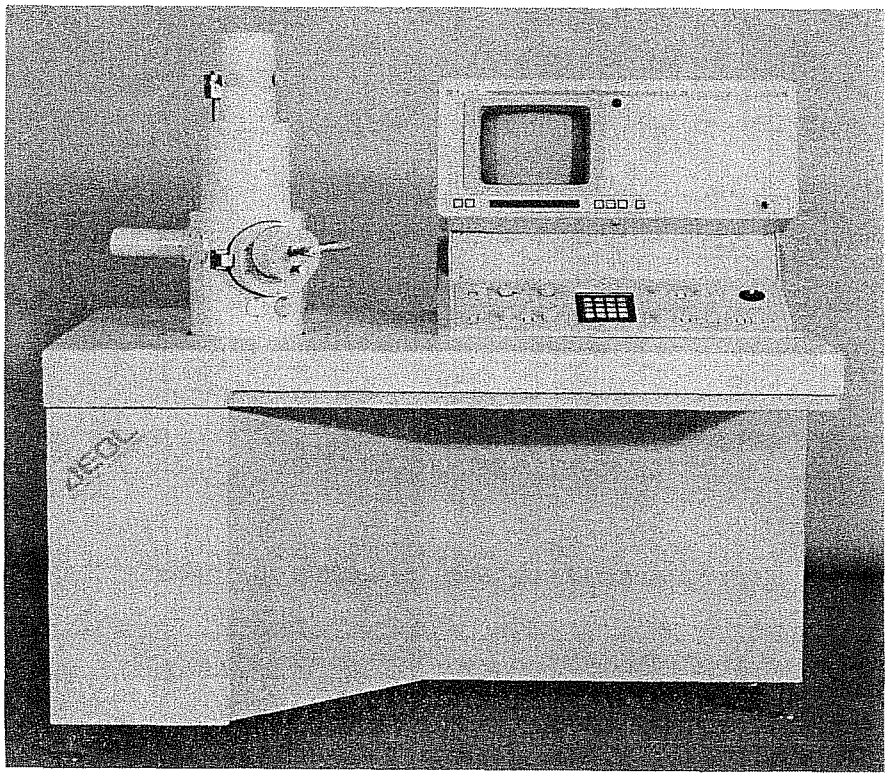
JEOL LTD./JEOL TECHNICS LTD.

Tokyo Japan

8810001KP

PREFACE

Although the instrument is easy to operate, you are requested to carefully read this instruction manual before starting its operation, for better understanding of keypoints on operation and for full comprehension of operational techniques.
This instruction manual (2nd Volume) covers the MAINTENANCE section.
Please refer to the OPERATION section in Instructions (1st Volume) for further details of specifications, panels and operation of the microscope.



Description of this instruction manual may be slightly different from the factual microscope due to its subsequent modification.

CONTENTS

5. MAINTENANCE I 5- 1
(Contents for 5. MAINTENANCE I)

5.1 Requirements for Maintenance 5- 2
5.1.1 Maintenance Points for Electron Optical System 5- 2
5.1.2 Other Maintenance Points 5- 4

5.2 General Cautions for Disassembly and Reassembly Procedures 5- 6

5.3 Cleaning 5- 9
5.3.1 Preparations for Cleaning Requisites and Tools 5- 9
5.3.2 Cleaning Procedures A and B 5-12

6. MAINTENANCE II 6- 1
(Contents for 6. MAINTENANCE II)

6.1 Precautions for Disassembly 6- 3

6.2 Column Disassembly/Reassembly Procedures 6- 4

6.3 Filament Replacement 6-11
6.3.1 Gun Filament Replacement 6-12
6.3.2 Alignment (of Optical Axis) 6-18

6.4 Clean Up a Set of Pole Pieces 6-24

6.5 Replacement of Objective Lens Aperture 6-28

6.6 Deflector Coil Disassembly 6-30

6.7 Scintillator Replacement 6-33

6.8 Lubrication of RP VENT Valve 6-36

6.9 Replacement of Oil Diffusion Pump (DP) Heater 6-39

6.10 Refilling of Oil in Oil Rotary Pump (RP) 6-40

6.11 Fuse Replacement 6-42

7. TROUBLESHOOTING PROCEDURE 7- 1
(Contents for 7. TROUBLESHOOTING PROCEDURE)

7.1 Trouble Checkup 7- 2

7.2 Trouble at Startup and Vacuum System 7- 3

7.3 Trouble with Image Quality 7- 6

7.4 Example of Trouble 7-11

APPENDICES

List of Accessories ..... A- 1

Standard Accessories and Tools I ..... A- 3

CHAPTER 5 MAINTENANCE I

(Basics: General Cautions And Cleaning)

CONTENTS

5.1 Requirements for Maintenance 5- 2
5.1.1 Maintenance Points for Electron Optical System 5- 2
5.1.2 Other Maintenance Points 5- 4
5.2 General Cautions for Disassembly and Reassembly Procedures 5- 6
5.3 Cleaning 5- 9
5.3.1 Preparations for Cleaning Requisites and Tools 5- 9
5.3.2 Cleaning Procedures A and B 5-12

REQUIREMENTS FOR MAINTENANCE

In the course of using the microscope for a long period of time, the following phenomena may be recognized and they make it difficult to obtain fine images as a result of contamination:

- o Burnout of gun filament
- o Increase of astigmatism/degradation of resolution
- o Instability of probe current/image disturbance due to jump of probe

The above contamination is caused by irradiation of electron beam. Besides, the component parts inside the column is also contaminated gradually by the sticking of evaporated and/or fine dust.
For solution to ensure the fine image at all times, so-called "Maintenance" is required to maintain the parts clean by periodically cleaning up some parts of microscope or by replacing the parts with new ones.

5.1 Requirements for Maintenance

5.1.1 Maintenance Points for Electron Optical System

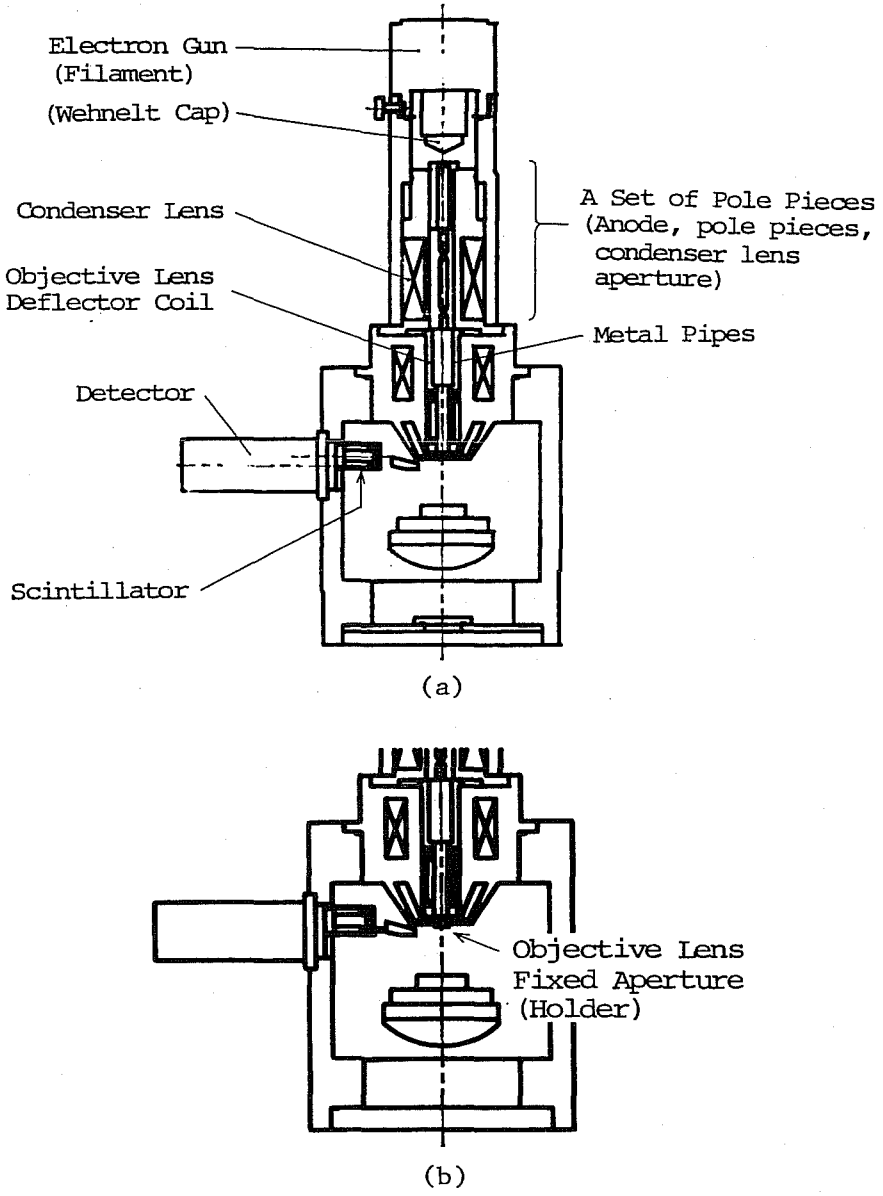


Fig. 5-1 Outline of Electron Optical System

Note: Fig. 5-1 shows the JSM-T330 example. The JSM-5200 differs somewhat in shape but maintenance is the same.

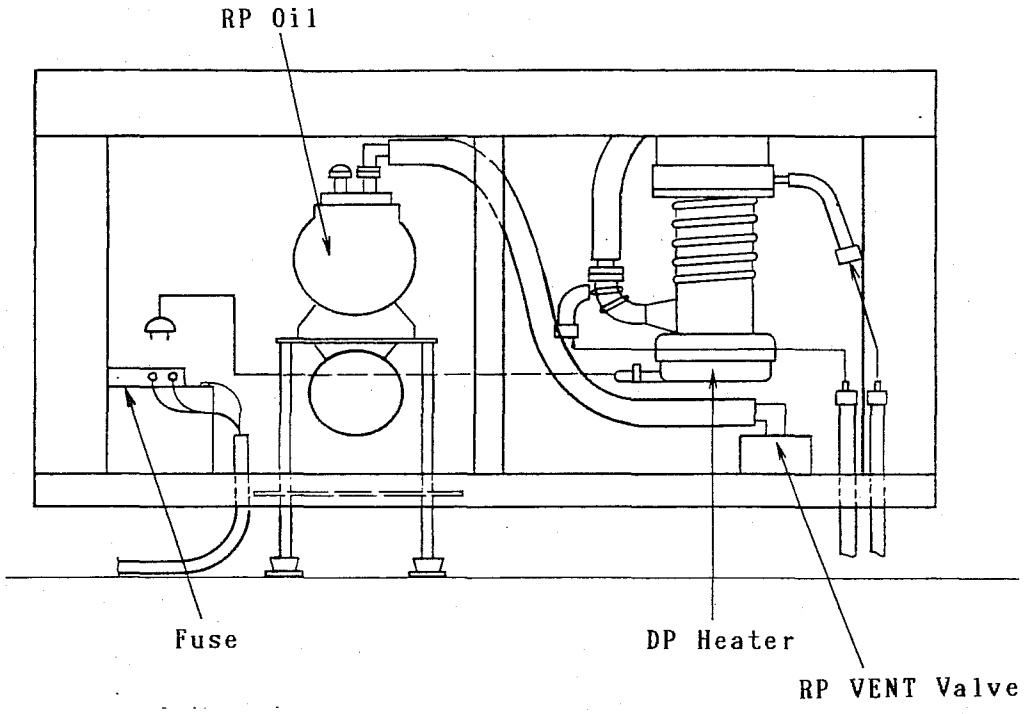
Maintenance Parts	General Maintenance Cycle	Maintenance Method	Reference Page
Filament	Burnout, fluctuation or deterioration	Replacement	6-11, 7-5
Wehnelt Cap	Together with filament replacement	Cleaning B	6-14, 7-5
Anode	1 to 2 years	Cleaning B	6-25
Condenser Lens Aperture	1 to 2 years	Replacement	6-25
Pole Pieces	1 to 2 years	Cleaning B	6-25
Objective Lens Aperture	1 to 2 years	Replacement	6-29, 6-32
Objective Lens Aperture Holder	Together with objective lens aperture replacement	Cleaning B	6-29, 6-32
Metal Pipe (In Deflector coil)	2 years	Cleaning A or B	6-34
Scintillator Chip	2 years	Replacement	6-37

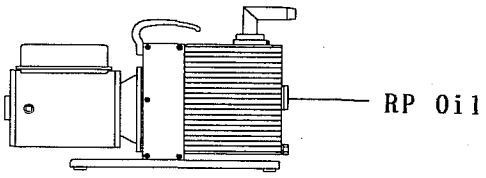
- o Cleaning A: The method of cleaning the parts with little dirt ... 5-12
- o Cleaning B: The method of cleaning the parts with much dirt 5-14

Table 5-1 Parts and Their Cycle of Maintenance

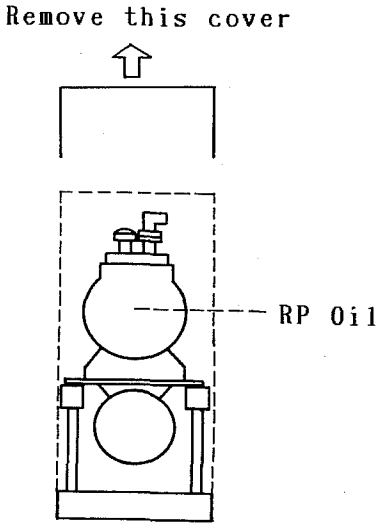
1. Perform the cleaning operation periodically so as to observe images always under the best condition.
2. Cleaning cycle depends on the frequency of using the microscope, but, if the contamination is recognized at a time earlier than the specified cleaning cycle time, shorten the cleaning cycle time.
3. Generally, as you turn [SPOT SIZE] control clockwise, probe current increases. This results in more contamination and the cleaning operation is required much more frequently. Besides, image observation at high resolution accelerates the degradation of resolution, and this also necessitates more frequent contamination.
4. Cleaning frequency also depends on the kinds of specimen to observe.

5.1.2 Other Maintenance Points





DRP



CRP

Fig. 5-2 Maintenance of Pump

Maintenance Parts	General Maintenance Cycle	Maintenance Method	Reference Page
RP VENT valve	1 year	Apply grease	6-40
DP Heater	At time of disconnection	Replacement	6-43
RP Oil	Insufficient	Add oil	6-44
Fuse	At time of blownout	Replacement	6-46

Table 5-2 Maintenance Cycle of Pump Related Parts

1. RP VENT Valve

   The vent valve which leaks automatically for RP at the time of microscope stoppage may not properly operate if the grease is insufficient for the piston to function as valve. Apply grease once a year.

2. DP Heater

   If the column is not evacuated and DP heater is not heated even 15 minutes after power application, the fuse may blow out and/or the DP heater or lead wire may be disconnected. Replace DP heater or lead wire if it is disconnected.

3. RP Oil

   Add oil if the oil level goes down below ● mark by consumption.

4. Fuse

   If it cannot start normally at power ON, it may be caused by the blow-out of fuse. Replace the fuse.

Note: To add or change DP oil for the reason that good vacuum condition cannot be ensured, please call our service engineer.

5.2 General Cautions for Disassembly and Reassembly Procedures

Here, the description covers general cautions for cleaning and 6. MAINTENANCE II (disassembly/reassembly of each component).
Perform the operation using a correct procedure with these cautions in mind.

1. Take special care for handling the component parts inside the column, since they are made with high precision.
   Example: Mount, dismount and disassemble parts by wearing clean gloves (made of cotton or nylon), but do not do the job with bare hands. If you forget it, dirt such as finger fat is stuck to the parts and may oxidize the parts. (Especially, care must be taken at the time of reassembly.)
2. Provide in advance a table and a cover to place the disassembled parts. The table should be a robust work table and should be covered with clean cloth or else as mentioned below, to prevent dust from sticking to the removed parts.
   Example: Gauze or rayon paper* is suitable for the parts from which stuck yarn waste can be easily removed. But, plastics sheet or Saran film is suitable for the parts with complicated shape. If you use plastics sheets, select ones that are unsoluble to organic solvent.
   As for the cover, use a plastics sheet, Saran film, or aluminum foil.
   For heavy parts, place something as a cushion (such as synthetic foam resin used for packing material) under the clean cloth and, then, place the parts after ensuring that any small piece such as screw is not left on the table.
   *Rayon paper: The paper without fluff and paper powder

3. Be sure not to damage the parts with the tool used for disassembly and reassembly as in the following examples.

   Examples: (1) Scratches or flaws to the parts by screwdriver, special tool, or tweezers
   (2) Damage to the parts by dropping them
   (3) Eccentricity or scuffing to be made by forcible mounting/dismounting of the parts
   (4) Disconnection of wired parts. (This must be avoided with special attention.)

   Note: The damage to parts may result in failure of reassembly, poor operability and deterioration of microscope performance.

4. Use the screwdriver, wrench, and other tools correctly and observe the following points especially when loosening or tightening the screw:

   Examples: (1) Select a screwdriver or a tool exactly to meet with the screw or the parts to be loosened.
   Then, loosen them by fully pushing them.
   (2) Tighten the screw and other parts, but not forcibly.
   First of all, make sure that they are the same as the ones removed. Then, tighten all the screws to be secured on the same face very lightly to the end.
   Finally, tighten each screw evenly and alternately little by little to the same proper torque.

   Note: If you neglect these cautions, the screw head may be damaged, the microscope affected by vibration and/or the screw thread damaged. Moreover, if you slip off the parts, the parts may be damaged. Even tightening is inevitable for reassembly of high-precision parts.

5. At the time of disassembly, sort and keep all the parts for easy reassembly.

   For example, keep small parts and screws in specially selected box or petri dish.

6. Those parts to be reassembled soon may be placed on the table. But, if the parts are to be left for a long time, they should be stored in a desiccator to protect them from oxidization. If a proper desiccator is not available, wrap the parts with the paper containing antioxidant, wrap them with Saran film together with a desiccating agent, further wrap them with aluminum foil, and keep them at a place of low humidity. This arrangement will produce the same effect as the desiccator.

5.3 Cleaning

Clean up chiefly the electron optical system. Also, apply grease to leak valve.

5.3.1 Preparations for Cleaning Requisites and Tools

Provide the following requisites and tools required for cleaning operation.

Requisites And Tools	Purpose	Caution	Recommendations
Thin Gloves for Work	Used to handle the component parts inside the column that must be especially free from dirt. The gloves can protect the parts from dirt by finger fat and oxidization by salt.	The gloves should be free from fluffs nor be dirty.	The gloves are made of cotton or nylon for clean room use and plastics gloves without powder are also applicable.
Ultrasonic Wave Cleaner	Used to finish clean the parts polished by fine grain metal polish and clean the dust off.	Wipe off fine-grain metal polish well and dip the parts in cleaning liquid in the beaker and put them in this ultrasonic wave cleaner as they are in the beaker.	Small type will do.
Handblower	Used to blow off the dust cleanly after cleaning operation.		(Accessories)

Table 5-3 Cleaning Parts (I)

Requisites And Tools	Purpose	Caution	Recommendations
Beaker	Used to contain the cleaning liquid.	Be careful of breakage if the beaker is made of glass.	The beaker made of stainless steel, aluminum and enamelled.
Standard Tool	Used to loosen/ tighten the screws.		(Accessories)
Tweezers	Used to mount/ dismount very small parts as difficult to handle with hands.	Take special care for handling these small parts.	(Accessories) For dentist and precision job
Brush	Used to remove fine grain metal polish with cleaning liquid from screws, etc.	Brush should not be spoilled by organic solvent.	Saran filaments embedded into bamboo
Mini Drill	Used to shorten the cleaning time by attaching cotton applicator to it.	Clean up the parts by attaching cotton applicator wound with absorbent cotton and applying fine grain metal polish. However, be careful not to polish excessively, as it has a strong polishing force.	
Gauze or Rayon Paper	Used to polish and wipe off the polish and to clean up the parts in details.	Use one that does not flow out impurities and is not fluffy.	Rayon paper should be crepe- or gauze-like.

Table 5-4 Cleaning Parts (II)

Requisites And Tools	Purpose	Caution	Recommendations
Cleaning Liquid (Organic Solvent)	Used to clean, degrease and remove fine grain metal polish. Cleaning A.	The solvent that has excellent cleaning ability with least impurities and high allowable density to human body, and is nonflammable. For application, be sure of the following points. (1) Ventilate the room well. (2) Do not dip fingers in liquid for long time.	Trichloro-ethane, aceton, alcohol or other volatile solvents
Absorbent Cotton	Used to polish, wipe off and clean up parts in details.	Select clean cotton and do not leave it onto the parts after polishing with it.	
Fine Grain Metal Polish	Cleaning B	This is paste form and easily removable by organic solvent.	(Accessories)
Cotton Applicator, Toothpick, Stick or Chopstick	Used to polish, wipe off and clean up parts well.	Use it by winding absorbent cotton or gauze around it. Approx. 5mm dia.	

Table 5-5 Cleaning Parts (III)

5.3.2 Cleaning Procedures A and B

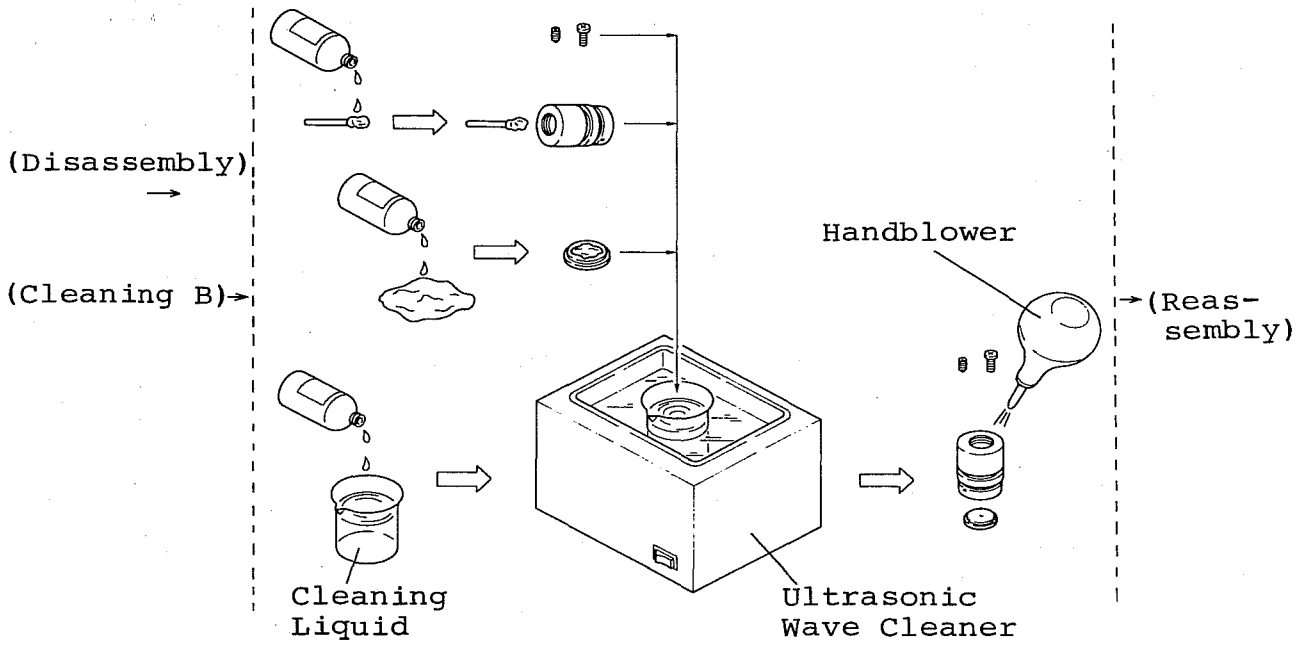


Fig. 5-3 Cleaning Procedure A

1. Cleaning Procedure A

Object: The method of cleaning the parts with a little dirt

Procedure: Wipe off the surface with gauze, rayon paper or absorbent cotton moistened with cleaning liquid (organic solvent). (But, use absorbent cotton to wipe off those sections that must be absolutely free from fine scratches.) For cleaning hole and bore of cylinder, use a cotton applicator, toothpick wound with absorbent cotton, stick or chopstick also wound with absorbent cotton, depending on the size of hole or bore. To remove oil and fat from the complicated shape or screw portion, apply the ultrasonic wave cleaner by placing them in the beaker or use the brush.

Cautions: (1) Do not use the brush to clean the parts which must be quite free from fine scratches.

(2) Use the handblower and blow off quickly the liquid deposited on the parts taken out of liquid so as to prevent residue from condensing.

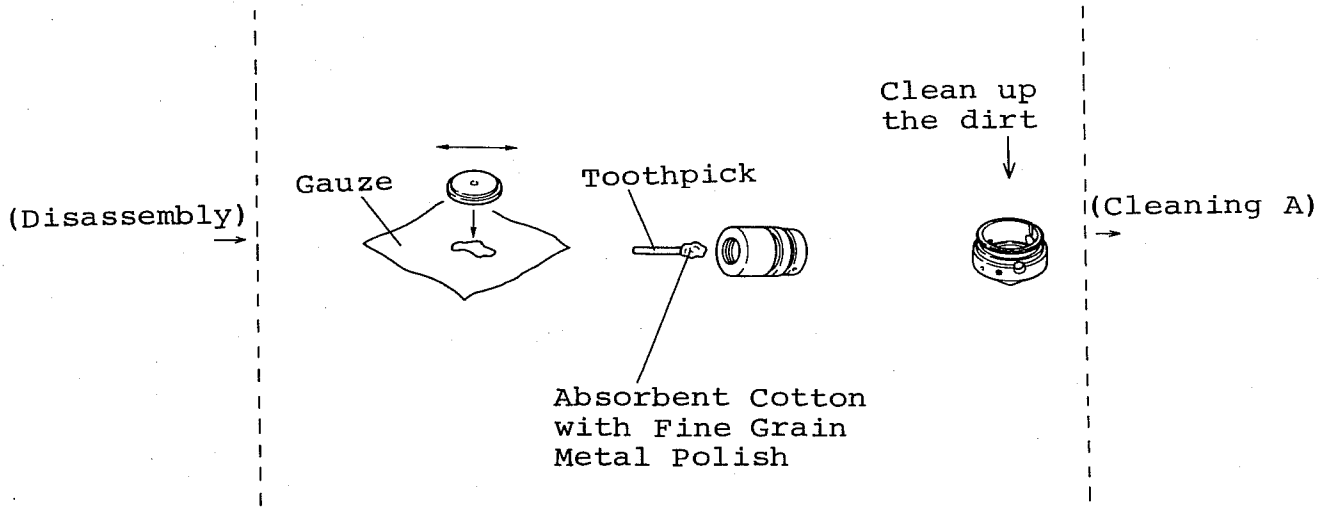


Fig. 5-4 Cleaning Procedure B

2. Cleaning Procedure B

Object: The method of cleaning the parts with much dirt

Example: Anode, Wehnelt cap, inside of the pole pieces, etc.

Procedure: (1) Polish the plane face with gauze, rayon paper or absorbent cotton by applying a small amount of fine grain metal polish to remove contamination and other stains and oxide. (Use absorbent cotton for polishing the sections that should be free from fine scratches.)

(2) For cleaning the dirt on hole and bore of cylinder, use a cotton applicator, toothpick wound with absorbent cotton, stick or chopstick also wound with absorbent cotton, depending on the size of the hole or bore.

Note 1: However, do not use the metal polish for cleaning the parts with complicated shape, screw or synthetic resin.

Note 2: To polish the parts, do not apply much force, but polish them smoothly with patience.

(3) Visual check is enough to ensure that the dirt and oxide are removed.

(4) In the end, remove the metal polish with cleaning liquid by repeating "Cleaning Procedure A" several times.

Note 3: If the metal polish is left on the parts, the polish residue itself is dirt, making cleaning operation meaningless.

Note 4: Additionally, to prevent dirt from sticking to the cleaned parts again, special attention should be paid to their storage. Until the time of reassembly, put aluminum foil over them.

CHAPTER 6 MAINTENANCE II

(DISASSEMBLY AND REASSEMBLY OF COMPONENT PARTS)

CONTENTS

6.1 Precautions for Disassembly 6- 3

6.2 Column Disassembly/Reassembly Procedures 6- 4

6.3 Filament Replacement 6-11

6.3.1 Gun Filament Replacement 6-12

6.3.2 Alignment (of Optical Axis) 6-18

6.4 Clean Up a Set of Pole Pieces 6-24

6.5 Replacement of Objective Lens Aperture 6-28

6.6 Deflector Coil Disassembly 6-30

6.7 Scintillator Replacement 6-33

6.8 Lubrication of RP VENT Valve 6-36

6.9 Replacement of Oil Diffusion Pump (DP) Heater 6-39

6.10 Refilling of Oil in Oil Rotary PUMP (RP) 6-40

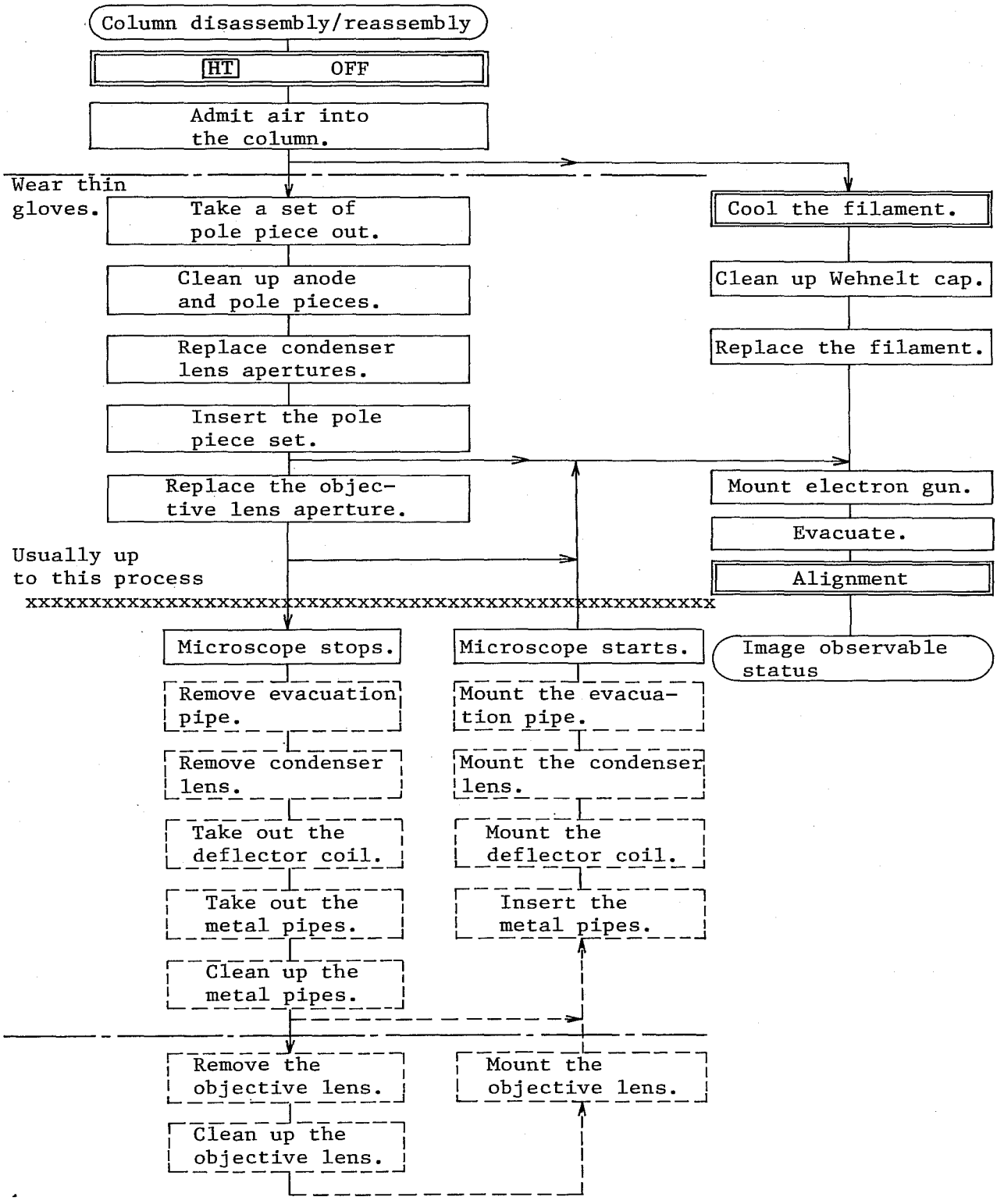
6.11 Fuse Replacement 6-42

6.1 Precautions for Disassembly

Perform disassembly/reassembly operations in correct sequence after again reading Chapter 5. MAINTENANCE I.
Refer also to Chapter 5. MAINTENANCE I for details of cleaning procedure of the disassembled parts.
To clean up as a result of any abnormality in observing the image, following operations are enough to correct it.
(1) Clean up Wehnelt cap and replace filament
(2) Clean up anode and pole pieces and replace condenser lens aperture.
(3) Replace objective lens aperture.

Removing parts not required for disassembly or parts requiring no cleaning makes reassembly operation time-consuming and may damage the parts. Additionally, put the aluminum foil over the exposed section that is not disassembled. Besides, if you touch the parts inside column, wear the thin gloves. But, be sure not to leave yarn waste of gloves inside the column. (Otherwise, yarn waste may be charged and affect the image adversely.)

6.2 Column Disassembly/Reassembly Procedures



1. Turn OFF [HT].
2. Press [VENT] and admit air into the column.
3. Remove alignment screws and take off electron gun.
4. If the filament is burnt out, replace the filament after it is cooled down.
   After replacing the filament, proceed to step 18 in this section.

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5. Wear thin gloves, but do not leave yarn waste of gloves inside the column (yarn waste may be charged and affect image adversely.)
6. Take out a set of pole pieces (refer to item 6.4 Clean Up a Set of Pole Pieces).
7. At this step, clean up anode and pole pieces and replace the condenser lens apertures.
   Proceed to step 18 in this section after cleaning and replacing as above.
8. Replace the objective lens aperture (refer to item 6.5 Replacement of Objective Lens Aperture).
   Note: Usually, cleaning and replacement up to this step are enough for the purpose.

--- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- ---

If any abnormality in image observation is still recognized after the above operation, refer to the CHAPTER 7 TROUBLESHOOTING PROCEDURE or please call our service engineer.

If you further proceed with the maintenance operation,

(1) Ensure again that the parts have been cleaned up or replaced properly.
(2) If cleaning and replacement have been not enough, repeat the operation.
(3) If the operation have been done properly, perform the following steps for cleaning the metal pipe (inside the deflector coil).

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

9. Stop the microscope and turn OFF the switch on distribution panel and wait for more than 30 min till the microscope cools down.
10. Remove evacuation pipe.
11. Remove 4 pieces of Allen screws and remove the condenser lens by pulling it upward (be careful when removing it, since it is heavy).
12. Check the mounting direction of deflector coil and take out the deflector coil (refer to item 6.6 Deflector Coil Disassembly).
13. Take out 3 pieces of metal pipes located inside the deflector coil by turning it upside down after covering the deflector coil with gauze so as not to damage them and not to drop them. (Refer to item 6.6 Deflector Coil Disassembly.)
14. Now, clean up the metal pipes.
15. After cleaning the deflector coil, reassemble the deflector coil with the following points in mind.
    (1) Reassemble it to the original configuration.
    (2) After starting the microscope, perform alignment of astigmatism correction coil at the image observable condition.

    Proceed to step 18 (reassemble condenser lens, evacuation pipe and electron gun in the reverse order of disassembly procedure and start the microscope).

    "Objective Lens Removal" is hardly required.

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16. Remove the upper section of objective lens and clean up if required.
17. Check that the objective lens movable aperture is taken out and, then, remove the lower section of objective lens and clean up if required.
18. After completing the clean-up operation and replacement as required, reassemble component parts in the reverse order of procedure with the following points well in mind. If the care is forgotten, cleaning effect becomes meaningless and it may cause vacuum failure. So, be sure to check up at each step of reassembly. The negligence of stepwise checkup may cause vacuum failure and this requires again to disassemble the parts, resulting in increase of job load.

(1) Perform dust prevention and dust collection.
Reassemble parts each time by ensuring that dust and yarn waste are not stuck on the parts. If they are stuck on the parts, remove the dust and yarn waste from the parts with a handblower during reassembly process. If it takes a certain time until proceeding to the next step of reassembly halfway on the reassembly operation, protect the reassembled parts and the parts to be reassembled from the dust by putting Saran film or aluminum foil over them.
Negligence of covering comes to no purpose of cleaning and causes high tension discharge and image disturbance.

(2) Check to see that the surface and contact face of O-ring have not scratches and yarn waste is not stuck on them.
Surplus vacuum grease causes the contamination of parts inside the column and of specimen and, accordingly, apply the grease in minimum for requirement. If any scratch is recognized on the metal of contact face, such parts may be usable when the depth of scratch is negligibly shallow. Or, the scratch can be corrected by polishing it in the direction in which the O-ring contacts super-fine grain sandpaper.
However, if the scratch is deep, call our service engineer for solution.

19. After mounting the electron gun, start the microscope if it has stopped.
20. Evacuate the column again and perform alignment for filament.
21. When the deflector coil is taken out, perform the alignment of astigmatism correction coil with the following procedure.

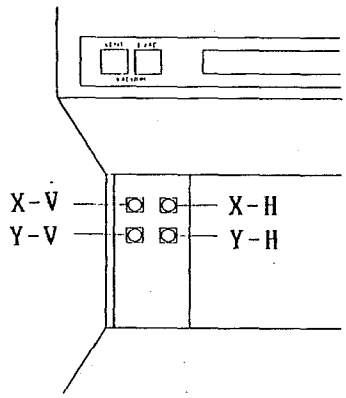


Fig. 6-1 Alignment of Astigmatism Correction Coil

(1) Mount standard specimen (ZnO) and evacuate the column.
(2) Adjust the focus and correct astigmatism with accelerating voltage at 25 kV, working distance at 20/10 mm, magnification at 50,000×.
(3) Turn the VR (installed at the back side of option panel) in the above Fig. 6-1 with the supplied screwdriver as follows:
   a) Adjust X-H and X-V alternately so that the image does not move even when turning [X] control of STIGMATOR.
   b) Similarly, adjust Y-H and Y-V alternately so that the image does not move even when turning [Y] control of STIGMATOR.

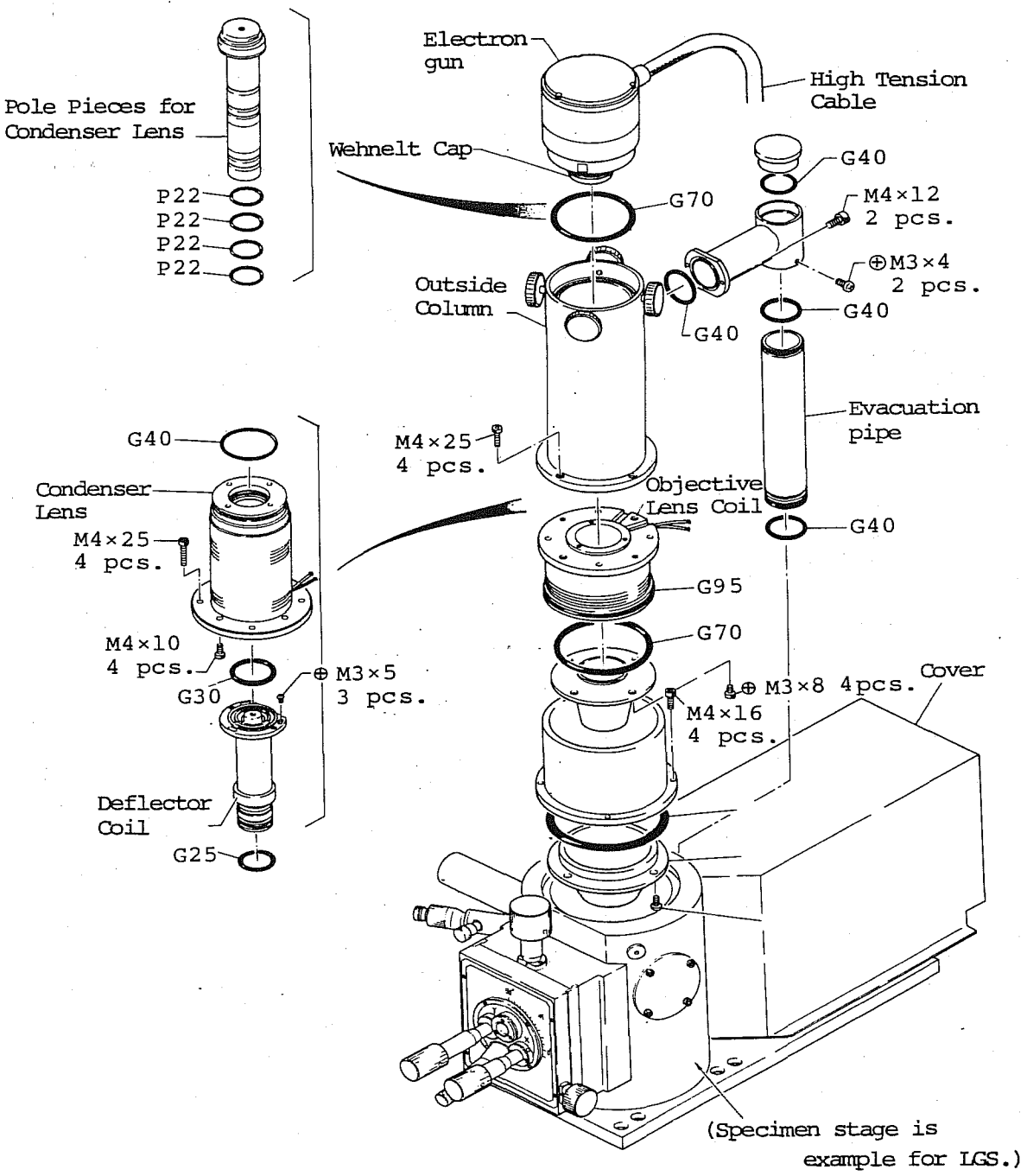
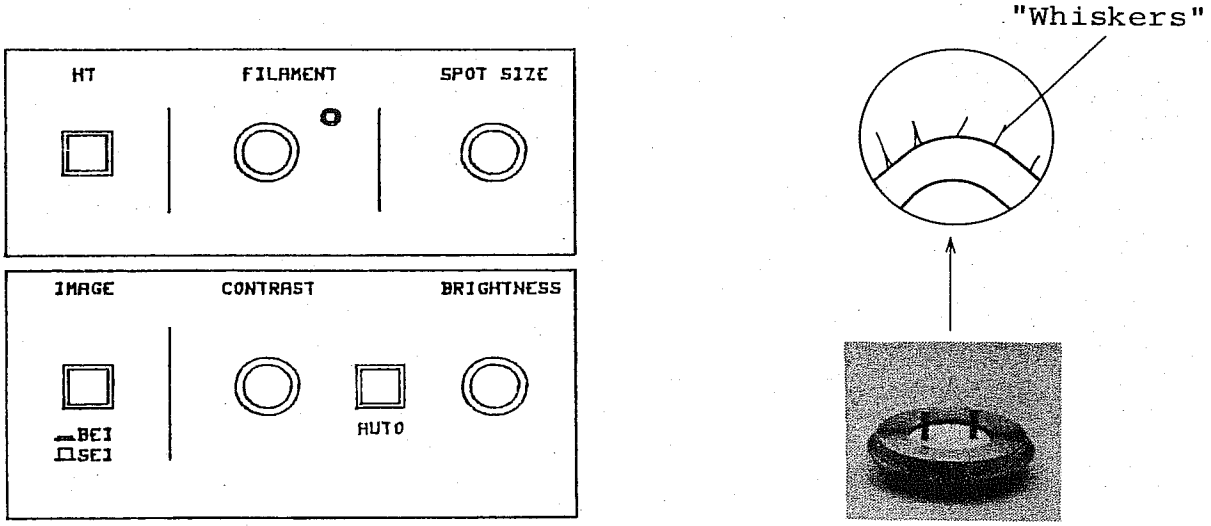


Fig. 6-2 Column Disassembly (I)

Note: Fig. 6-2 is an JSM-T330 example. The JSM-5200 differs in shape but does not in disassembly.

6.3 Filament Replacement



a. Filament Monitor Lamp

b. Filament Checkup

Fig. 6-3 Filament Replacement

****

Filament replacement is required in the following cases.

(1) The image does not appear and filament monitor lamp does not light even when turning [FILAMENT] knob clockwise beyond 11 o'clock with [HT] ON (gun filament is burnt out in this case).

(2) The [L.C] value of the filament load current fluctuated. So, filament was checked and whiskers were recognized (whisker-like substance can be seen with 15× loupe).

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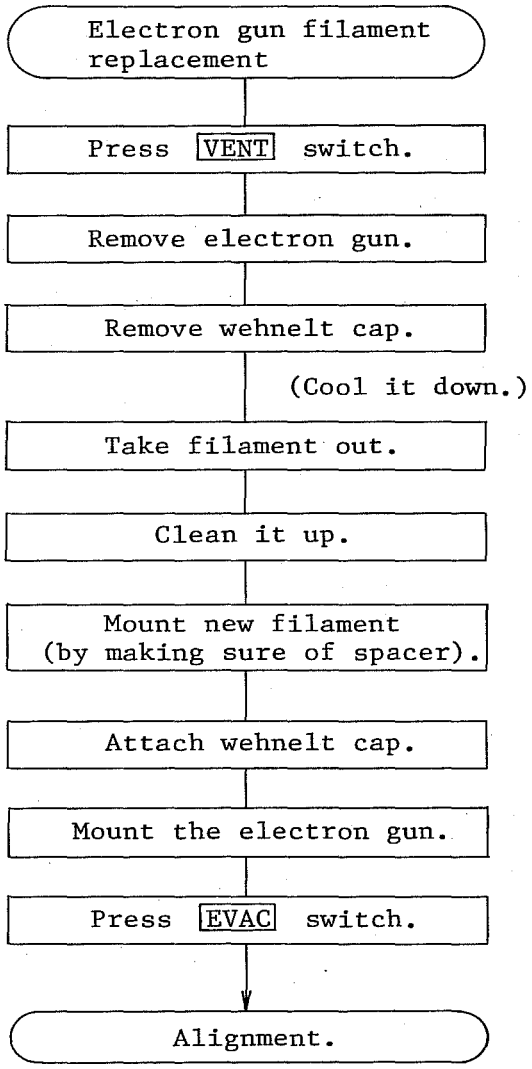
6.3.1 Gun Filament Replacement



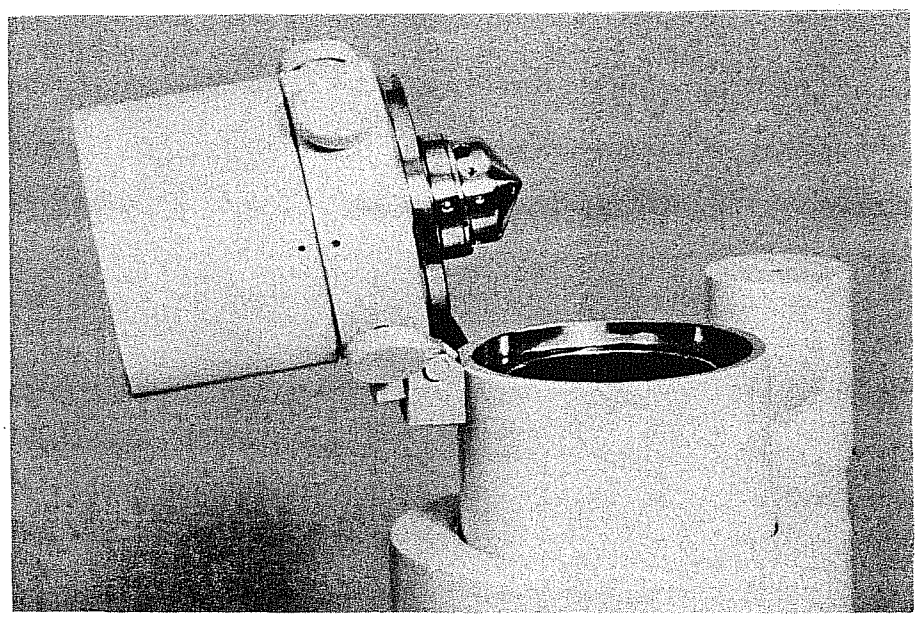


Fig. 6-4 Electron Gun Removal

The column and specimen chamber are exposed to air at the time of filament replacement and this requires completing the operation in the shortest possible time by observing the operation procedure.

1. Expose the column to atmospheric pressure (press the evacuation operation switch [VENT]).
2. Loosen alignment screws (4 pieces) and remove the electron gun. (refer to Fig. 6-4)
3. Put Wehnelt cap removing tool on Wehnelt cap and tighten it with fixing screw.

   Note: Handle carefully the wehnelt cap just after use because it is at high temperature.

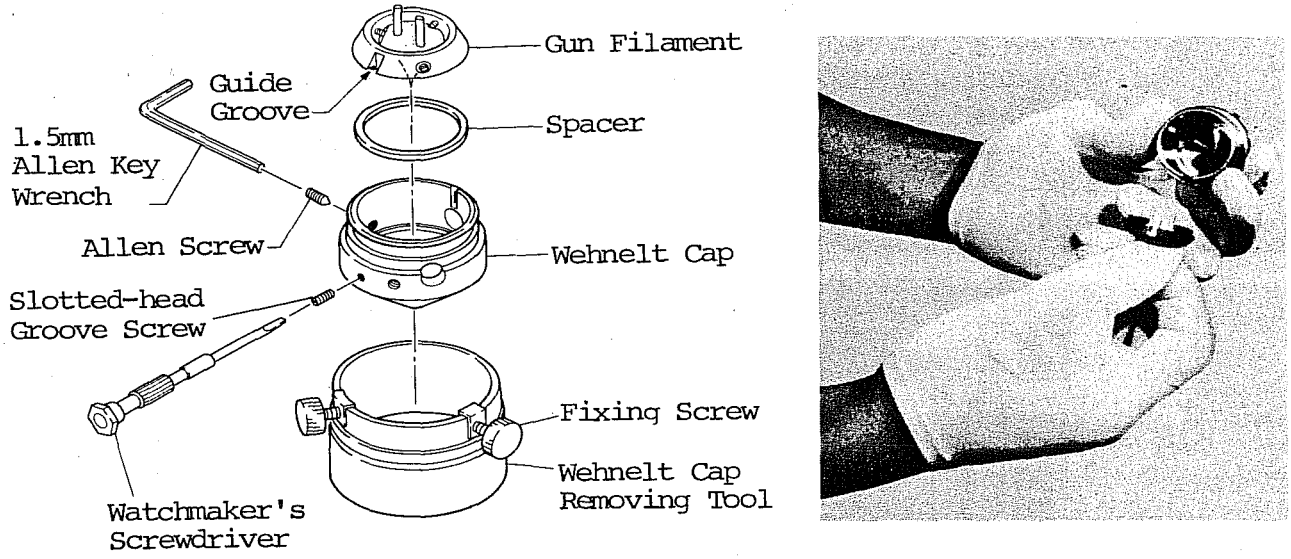
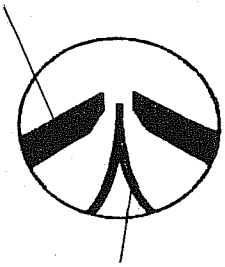


Fig. 6-5 Filament Removal

4. Pull Wehnelt cap removing tool upward and remove the Wehnelt cap from the main body and cool it down enough.
5. Return the electron gun to original position.
   (Evacuate it if cleaning takes much time.)
6. Loosen 2 pieces of fixing screws and remove the Wehnelt cap removing tool from Wehnelt cap.
7. Loosen Allen screws (3 pieces) of Wehnelt cap with Allen key wrench. Slotted-head groove screw is used as a pin to set the filament in the same direction and Allen screws are used to fix the filament.
8. Loosen the slotted-head groove screw with watchmaker's screwdriver and take out the gun filament.

9. Clean up the wehnelt cap.

Caution for Cleaning Wehnelt Cap



Eliminate contamination especially at the inside near the lead end of filament with the fine grain metal polish. It is recommended to polish it with a tooth-pick wound with gauze. Be careful not to polish it excessively; otherwise, hole diameter may grow larger. Additionally, finish (clean) it carefully and sufficiently.

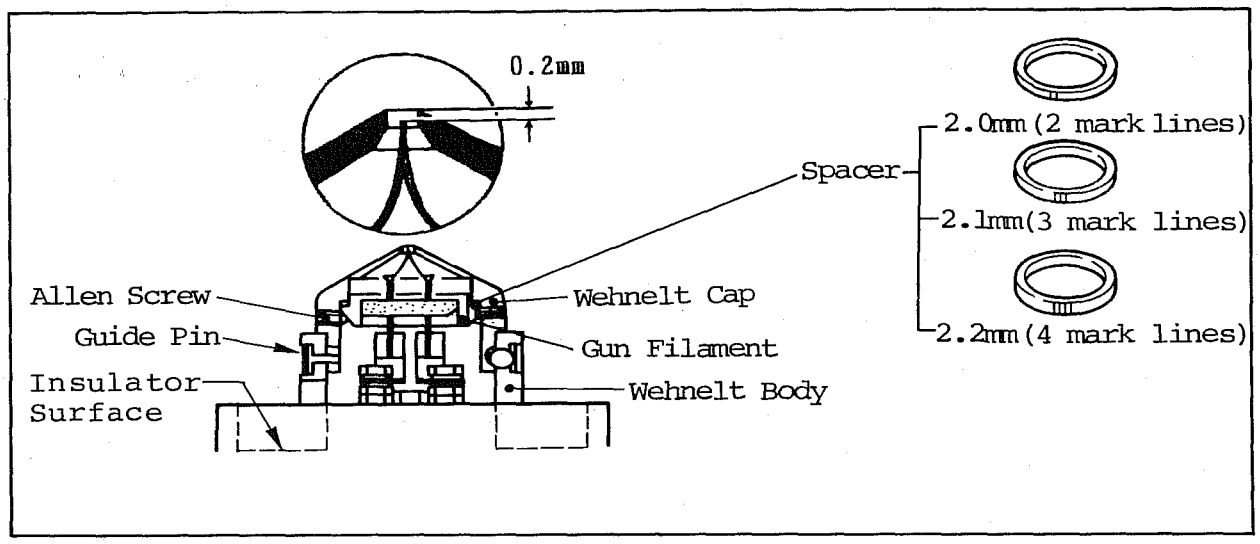


Fig. 6-6 Filament Replacement

10. Screw in slotted-head groove screw halfway to the wehnelt cap.
11. Install a new electron gun filament to the wehnelt cap by aligning it's guide groove with the pin, and secure it by tightening the allen screws (three) and the slotted-head grooved screw.

    Note: . Usually, a 2.1 mm spacer (3 mark lines) is set so that the tip of the electron gun filament is about 0.2 mm short of the wehnelt cap.

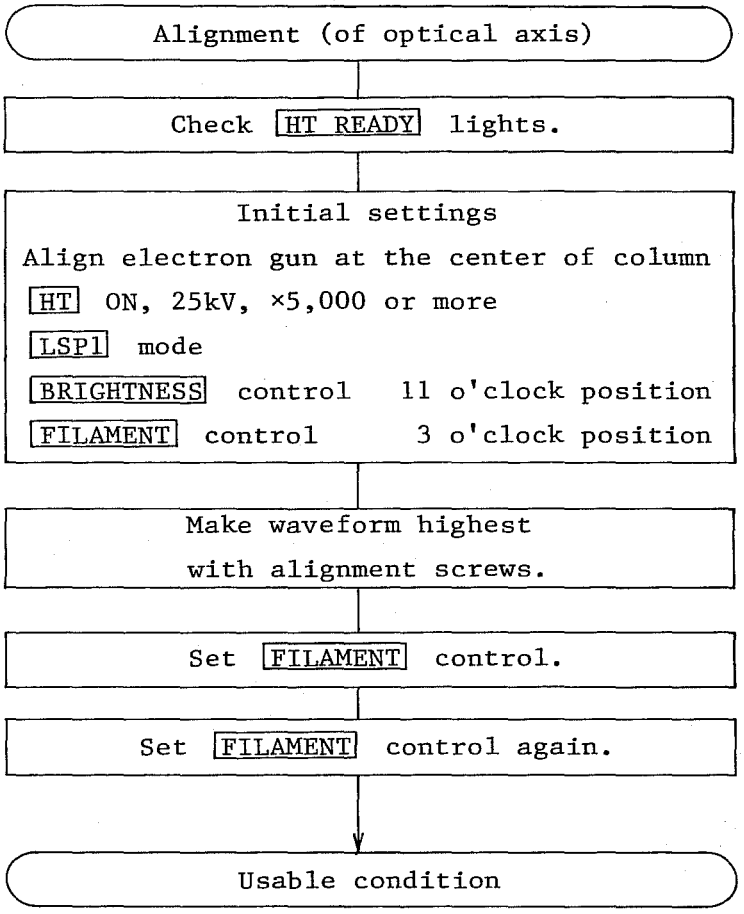
    If the tip of the electron gun filament protrudes from the wehnelt cap when a 2.1 mm spacer is used, employ a 2.2 mm spacer (4 mark lines).

    . A 2.2 mm spacer is suited to keep longer the life of filament since it depends on the load current.

    A 2.0 mm spacer is suited to observation under high brightness and high resolution.
12. Pull up the electron gun. (Admit air if evacuated.)
13. Clean up the glass surface of electron gun, if it is dirty.
14. Attach wehnelt cap onto wehnelt body by meeting the guide pin with pin groove.

15. Blow away the dust and lint around the wehnelt unit with a handblower and mount the electron gun on the column.
16. Evacuate the column again. (Press the VACUUM [EVAC] switch.)
17. Perform alignment when the evacuation sequence [HT READY] on LCD lights up. (refer to item 6.3.2 Alignment)

6.3.2 Alignment (of Optical Axis)



Perform alignment adjustment so that the electron gun faces the optical axis, after replacing gun filament, replacing and cleaning objective lens aperture or disassembling the column.

****

o Adjust [FILAMENT] control every several hours on the day of replacement.

Especially, adjust every 10 min. for 1 hour just after replacement.

****

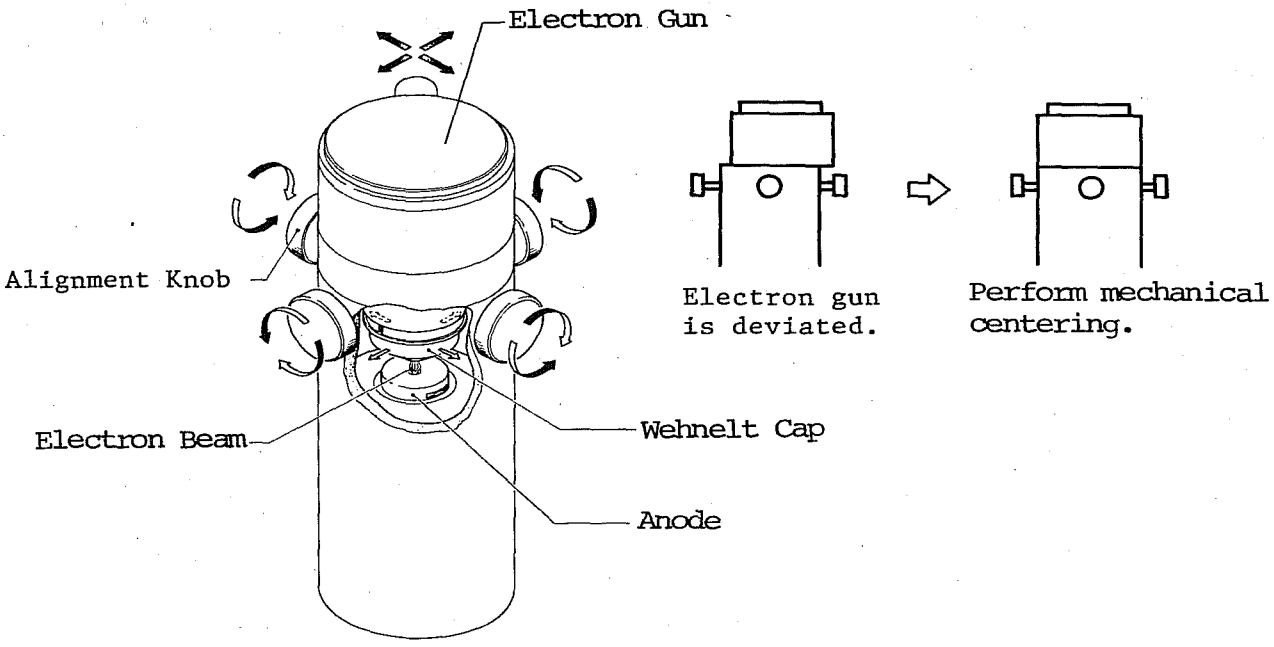


Fig. 6-7 Movement of Alignment Knob And Electron Gun

1. Evacuate and check that the evacuation sequence HT READY on LCD lights up.
2. Fix the electron gun temporarily by positioning it to the center of column with alignment knobs (4 pcs.)
   (Caution for Turning Alignment Knob)
   Be sure to turn the left-side knob counterclockwise when the right-side knob is turned clockwise, so as to always secure the electron gun.

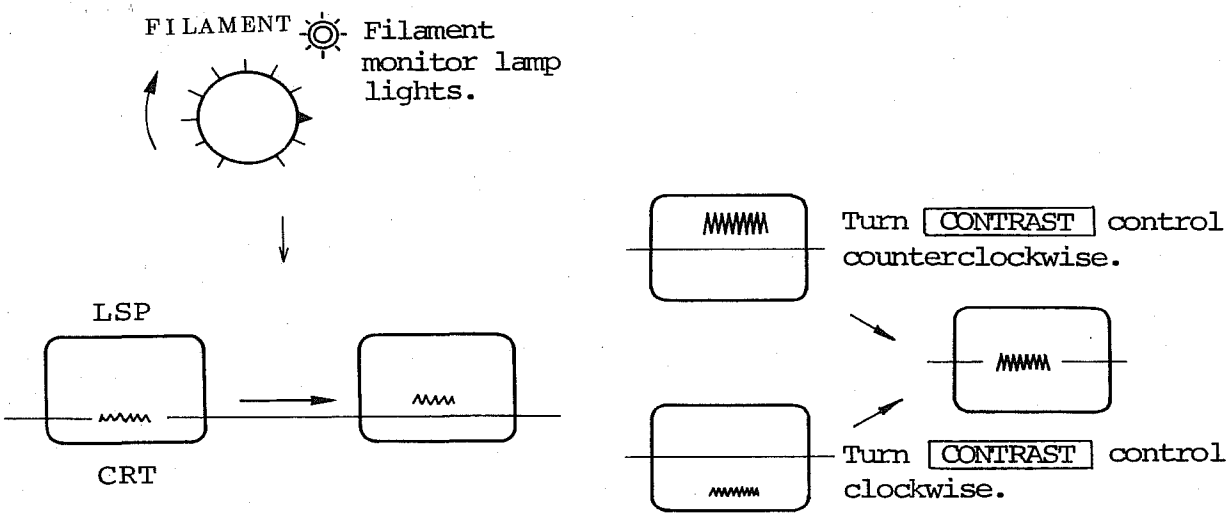


Fig. 6-8 Electron Gun Alignment

3. Set up as follows:

HT switch:	ON (LED lights up)
ACCV△ key:	25 kV
SCANNING MODE LSP1 key:	Pressed
MAGNIFICATION switch:	Above 5,000x
BRIGHTNESS control:	11 o'clock position
FILAMENT control:	Near 3 o'clock

4. Make sure that the filament monitor lamp lights.

   Note 1. If the filament monitor lamp does not light, replace gun filament with a new one, because the filament is burnt out.

   2. If FILAMENT control is set beyond 3 o'clock position, filament may be overheated and burnt out.

5. Adjust the position of electron gun with alignment knobs (4 pcs.) so that the waveform on CRT screen moves to highest position.

   Note : If the waveform moves only a little or too largely up to the upper limit of screen, move the waveform to the center of CRT screen with [CONTRAST] control.

6. Return [FILAMENT] control to 9 o'clock.

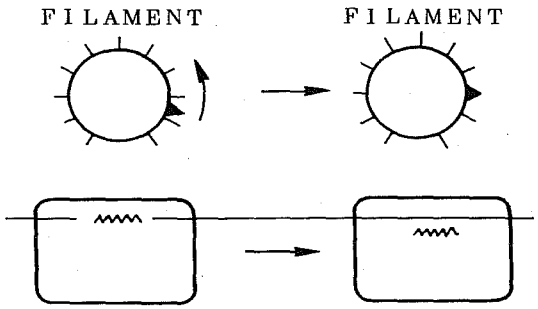


Fig. 6-9 Adjusting [FILAMENT] control

7. Set the applicable position of [FILAMENT] control.

   (1) Make sure that it is near to the ideal curve in Fig. 6-10.

   (2) While monitoring the waveform on the CRT screen, return [FILAMENT] control slightly counterclockwise and set it to the position just before the waveform starts a drastic drop (position just lower than saturation point: Position A in Fig. 6-10).

   Note 1. The height of 1st peak and that of the saturation position are different depending on condition of filament. And, there may be a case that 1st peak is higher than saturation position if the filament is a new one.

   2. If alignment is insufficient, waveform goes down when turning the control further clockwise from saturation position. Here, perform alignment again.

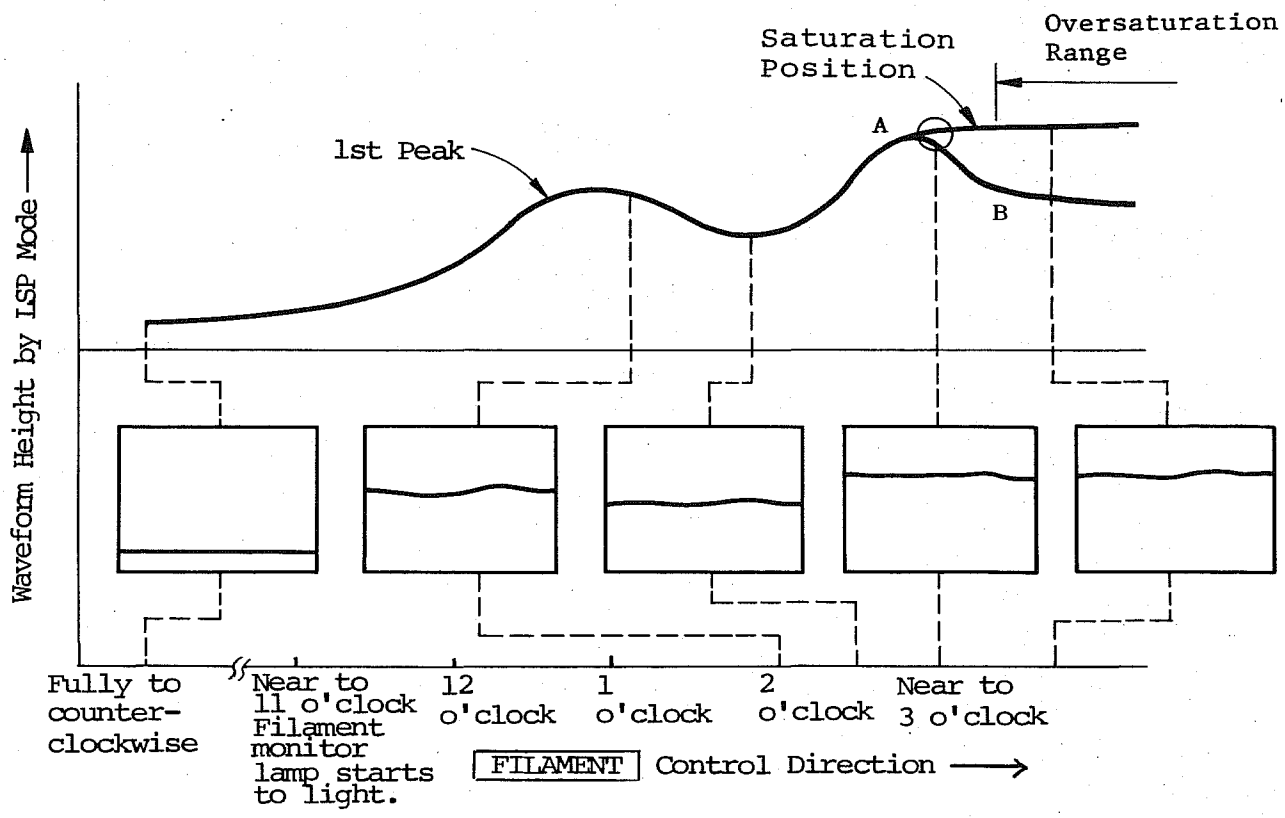


Fig. 6-10 Setting FILAMENT Control

8. Set FILAMENT control again to its final position.

Note 1. If the gun filament is used at the oversaturation condition, it may shorten the service life of gun filament and bend the filament.

2. Observe the following points for adjusting FILAMENT control by monitoring the L.C value of checker.
   (1) Set the control so as not exceed 150μA.
   (2) Clean up Wehnelt cap if fluctuation is recognized. Here, if the filament has whiskers, replace it with a new one (the whiskers can be seen with loupe 15×).

3. As in B of Fig. 6-10, if waveform lowers when turning around 3 o'clock, it shows insufficient alignment. For solution, turn FILAMENT control a little past 3 o'clock and perform realignment.

6.4 Clean Up a Set of Pole Pieces

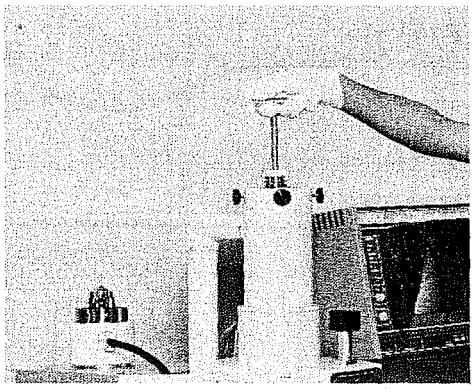


Fig. 6-11 Pole Pieces Removal

Remove the electron gun. Then, pole pieces can be taken out by the supplied tool without disassembling the column. Just by taking out a set of pole pieces, you can clean up the anode and pole pieces, and replace condenser lens apertures.

1. Check the following points.
   (a) Press the vacuum control switch [VENT] and admit air into the column.
   (b) The electron gun is removed (cover it with aluminum foil).
2. Enter the pole piece removing tool in the groove of anode and loosen the anode counterclockwise. Then, take it upward very carefully to take out pole pieces (refer to Fig. 6-11).

   Note (1). Be careful not to drop pole pieces nor to damage the nearby parts when you take out the pole pieces.
   (2). Do not touch pole pieces with bare hand, but wear the gloves to handle them.
   (3). Proceed to next operation after pole pieces are cooled down enough. Aperture holders (① and ②) may be scuffed if turning them before cooling them down. (Refer to Fig. 6-12)
   (4). Fig. 6-11 differs somewhat in shape but removal is the same.

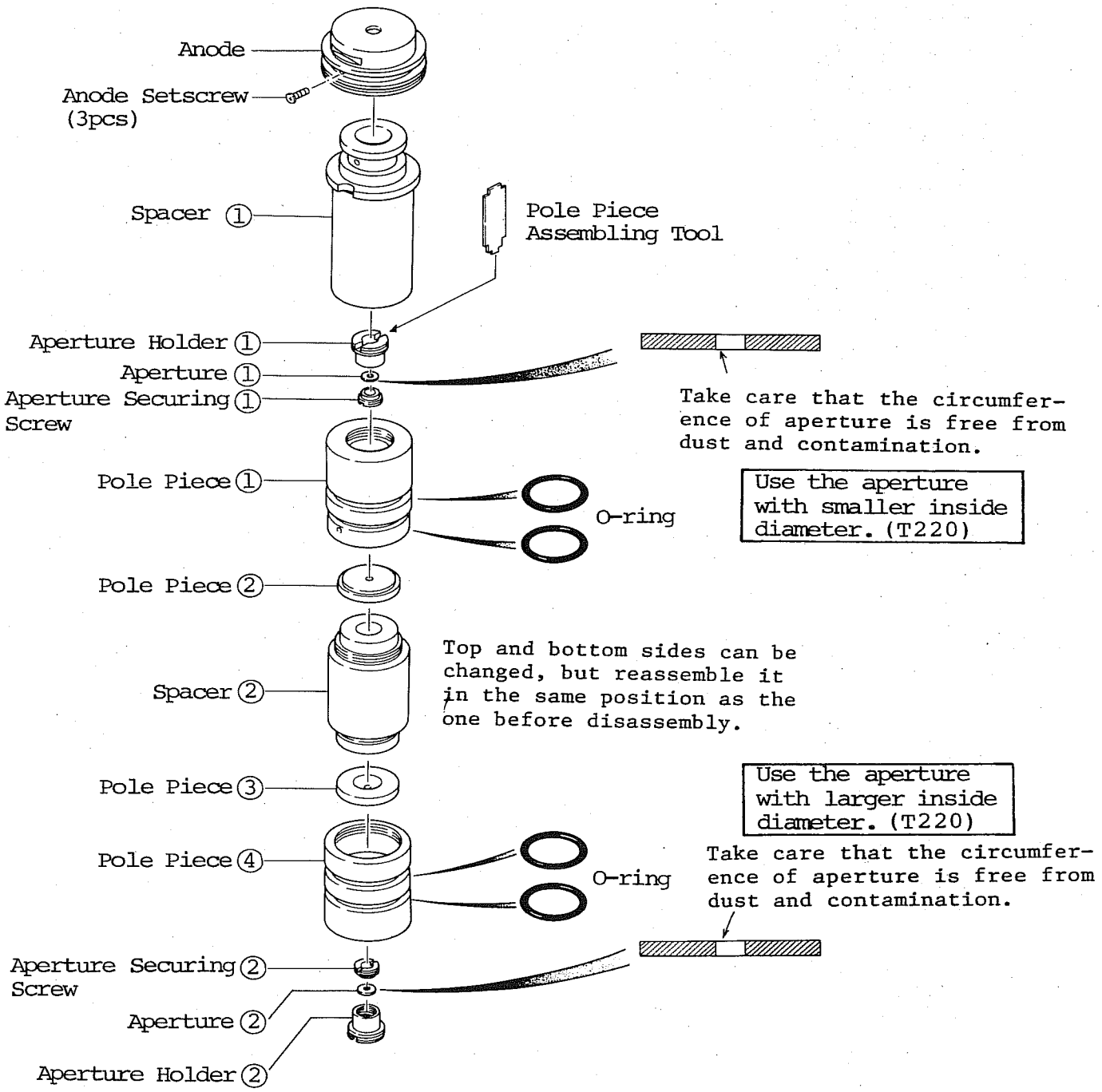

Anode
Anode Setscrew (3pcs)
Spacer ①
Pole Piece Assembling Tool
Aperture Holder ①
Aperture ①
Aperture Securing Screw ①
Take care that the circumference of aperture is free from dust and contamination.
Pole Piece ①
O-ring
Use the aperture with smaller inside diameter. (T220)
Pole Piece ②
Spacer ②
Top and bottom sides can be changed, but reassemble it in the same position as the one before disassembly.
Pole Piece ③
Use the aperture with larger inside diameter. (T220)
Pole Piece ④
O-ring
Take care that the circumference of aperture is free from dust and contamination.
Aperture Securing Screw ②
Aperture ②
Aperture Holder ②

Fig. 6-12 Disassembling Pole Piece of Condenser Lens

Cautions for Cleaning

o Pole Pieces

Apply Cleaning Procedure B.

Remove contamination from the inside wall of a hole very carefully by polishing it so as not to damage it.

Especially, take care not to damage the edge of the hole.

Do not use the brush for this cleaning.

Finish cleaning carefully using Cleaning Procedure A.

o Condenser Lens Aperture

Replace the lens aperture with a cleaned lens aperture purchased from JEOL Ltd.

Condenser Lens	Gap I.D	Aperture I.D	
Upper	Large	Aperture (1)	Small
Lower	Small	Aperture (2)	Large

Disassemble pole pieces by referring to Fig. 6-12.

3. Remove spacer (1) from pole piece (1) (Fig. 6-12) and loosen the aperture holder (1) with assembly tool. Then, remove the pole pieces (Fig. 6-12).
4. Loosen the aperture (1) with the assembly tool and remove it from the aperture holder (1).
5. Remove the aperture (2) similarly as described in item 4 and 5 above.

   Note: The aperture (1) is secured inside the aperture holder (1) by the aperture securing screw (1).

   The aperture (2) is also secured inside the aperture holder (2) by the aperture securing screw (2).
6. Clean up parts other than condenser lens aperture by Cleaning Procedure B.

7. Replace the condenser lens aperture (1) and the aperture (2) with cleaned ones.

   Note: The cleaned condenser lens aperture can be purchased from JEOL Ltd.

8. After cleaning operation, reassemble them in the reverse order of procedure, with the following points in mind.

   (a) Although the aperture holders (1) and (2), and the aperture securing screws (1) and (2) are same, their mounting positions are different and, accordingly, carefully reassemble them in their original positions.

   (b) Although the spacer (2) can be placed upside down, place it in the same side as before disassembly.

   (c) The pole pieces (1), (2), (3) and (4) cannot be placed in a different side; each of them should be placed in the same direction as before disassembly.

9. Now, clean up the other parts.

   If the other parts are not to be cleaned (or cleaned already), insert the pole pieces inside the column with the pole piece removing tool.

10. Return the electron gun to the original position, taking care not to fly the dust away (such as by blowing with handblower) and evacuate it again.

6.5 Replacement of Objective Lens Aperture

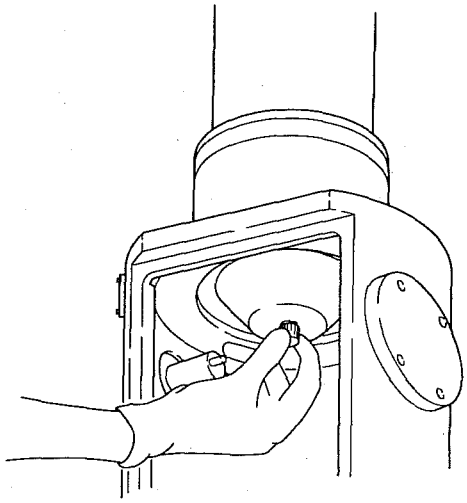


Fig. 6-13 Removal of Objective Lens Aperture Holder

Clean up the tweezers and the fixed aperture removing tool in advance by Cleaning Procedure A.

1. Admit air into the column (press [VENT]).
2. Take out the specimen stage from the specimen chamber and cool the aperture holder for about 10 min.
3. Place the supplied fixed aperture removing tool to the objective lens aperture holder, turn it counterclockwise as viewed from the bottom, and take out the objective lens aperture holder (refer to Fig. 6-13).
4. Turn the cap counterclockwise and take out both the spacer and aperture carefully (Fig. 6-14).

   Note (1). Take care that the spacer and aperture not damaged or bent by the tweezers. Also, be sure not to lose them, since they are small pieces.

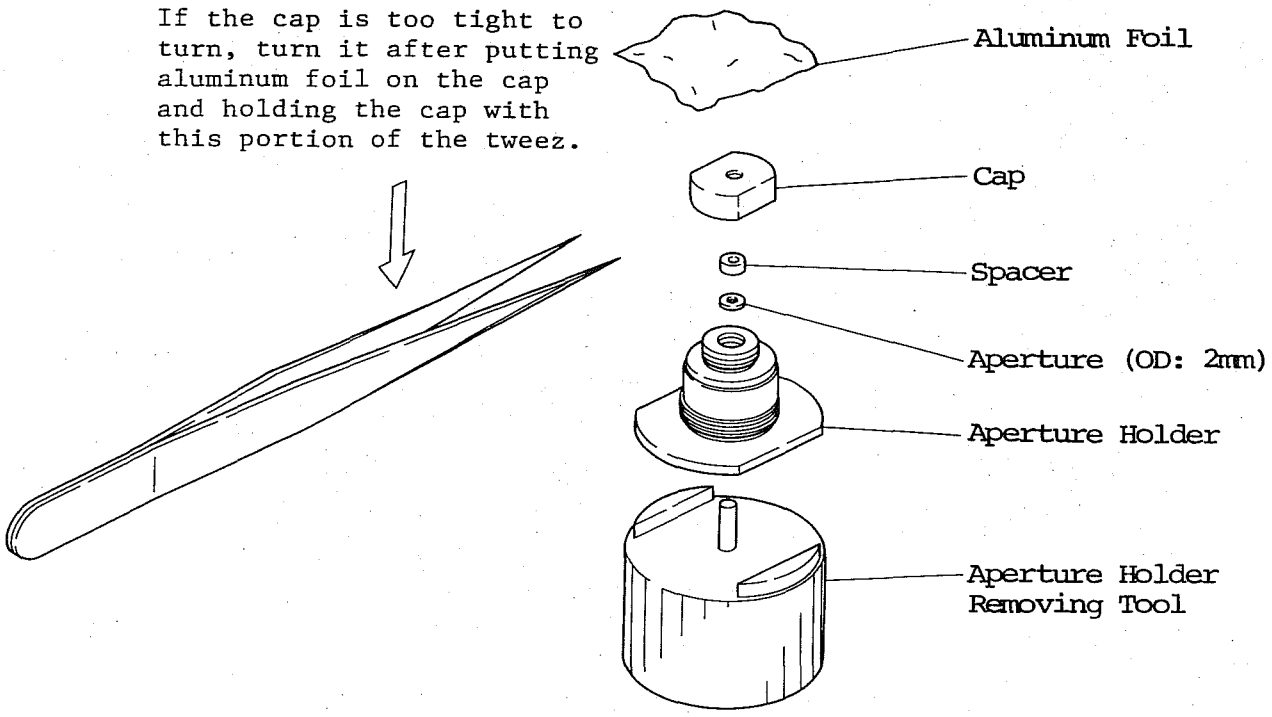

If the cap is too tight to turn, turn it after putting aluminum foil on the cap and holding the cap with this portion of the tweez.
Aluminum Foil
Cap
Spacer
Aperture (OD: 2mm)
Aperture Holder
Aperture Holder Removing Tool

Fig. 6-14 Objective Lens Aperture Disassembly

Note (2). If the aperture cannot be removed from the holder, push it lightly from the rear side with such a tool as a toothpick that does not damage it.

5. Clean up the cap, spacer and aperture holder by Cleaning Procedure B. Here, clean them up very carefully till no contamination is left.
6. Replace the fixed aperture with a cleaned one.
   Note: Cleaned apertures can be purchased from JEOL Ltd.
7. After cleaning, carefully place the fixed aperture and spacer into the aperture holder with tweezers and screw in the cap.
   At this time, do not touch the cleaned holder, cap, spacer and aperture with bare hand.
8. Attach the aperture holder to the objective lens.
9. Return the specimen stage to specimen chamber and press the EVAC switch to evacuate the column.

6.6 Deflector Coil Disassembly

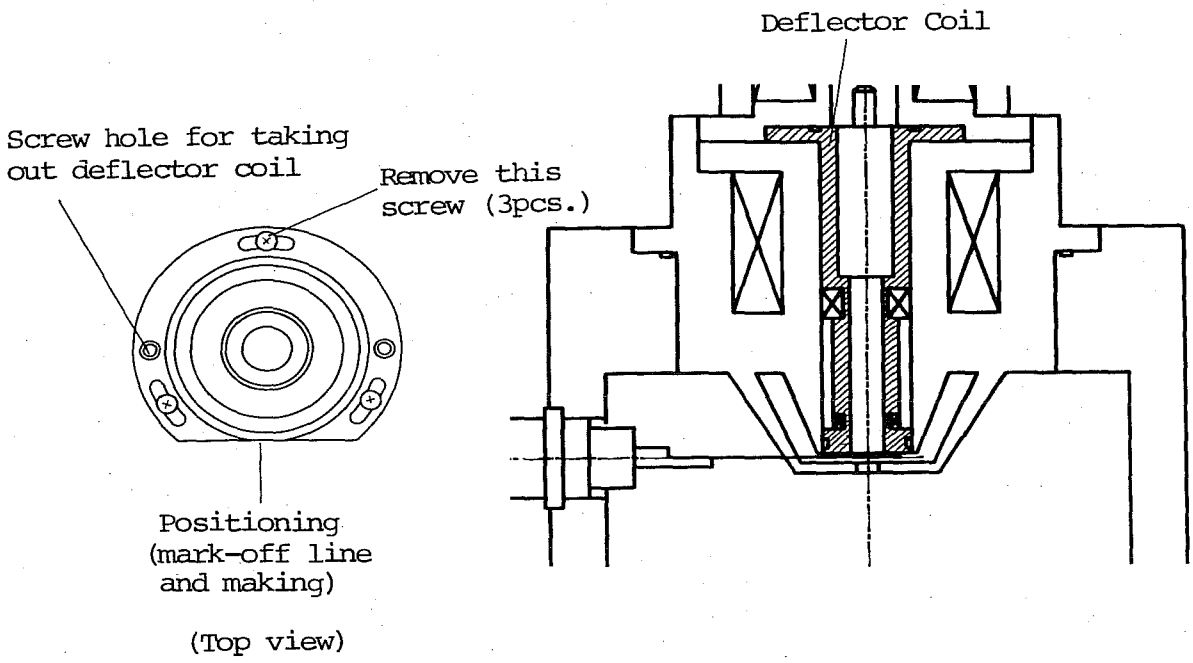

Deflector Coil
Screw hole for taking out deflector coil
Remove this screw (3pcs.)
Positioning (mark-off line and making)
(Top view)

Fig. 6-15 Deflector Coil Removal

Take out the deflector coil only when it is necessary with reference to item 6.2 Column Disassembly/Reassembly Procedures. Take out the deflector coil vertically by referring to the drawings of Column Disassembly (I) in Fig. 6-2,most carefully not to contact the other parts.

1. Check the following points before starting the disassembly of deflector coil.
   (1) Power supply to the microscope is cut off.
   (2) Condenser lens is removed.
2. Check up the secured position before taking out the deflector coil.

3. Remove 3 pieces of screws that secure the deflector coil. Screw in 2 pieces of M4 × 25 bolts to the deflector coil pulling holes and pull it up slowly.
4. When the deflector coil is taken up about 5 to 10 mm, pull it out vertically by holding the screws.
5. Pull out the metal pipe by removing coil spring and pipe retainer.
6. Clean up the metal pipe by Cleaning Procedure B.
7. If the electrode is dirty, clean it up also by Cleaning Procedure B.
8. After completing the cleaning, reassemble them in the reverse order of disassembly procedure and install after positioning.
   Note: Be sure not to place lead wire between them.
   (If it is placed between, it may be disconnected.)
9. After reassembling the condenser lens and the electron gun, evacuate the column and perform the alignment of the electron gun.
10. Align the astigmatism correction coil (refer to item 6.2 Column Disassembly/Reassembly Procedures).
    Note: Fig. 6-15 differs somewhat in shape but disassembly is the same.

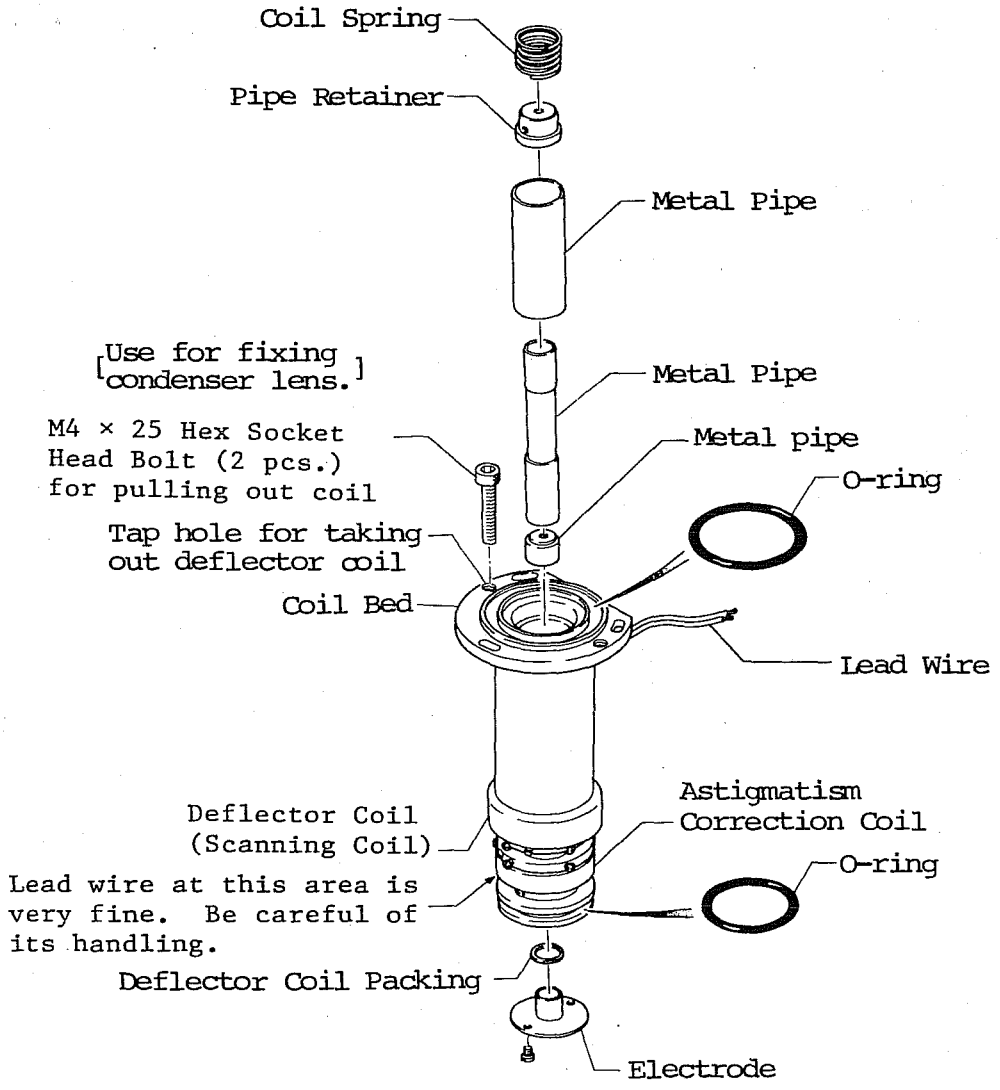


Fig. 6-16 Deflector Coil Disassembly

Note: The JSM-5200 differs somewhat in shape but disassembly is the same.

6.7 Scintillator Replacement

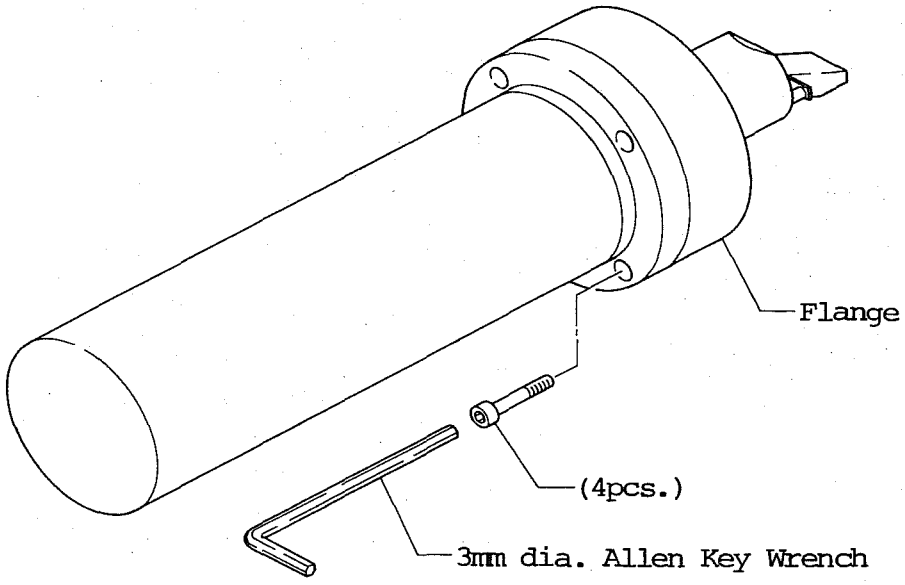


Fig. 6-17 Detector Removal

Scintillator should be replaced in any one of the following cases:
When the aluminum coating on the scintillator has pealed off or phosphor has deteriorated due to long-time use (image is much noisy.), the scintillator must be replaced.

1. Make sure that the air in the column is at atmospheric pressure and the microscope is at a stop.
2. Loosen 4 pieces of Allen screws that tighten the detector and remove the detector from specimen chamber (refer to Fig. 6-17).

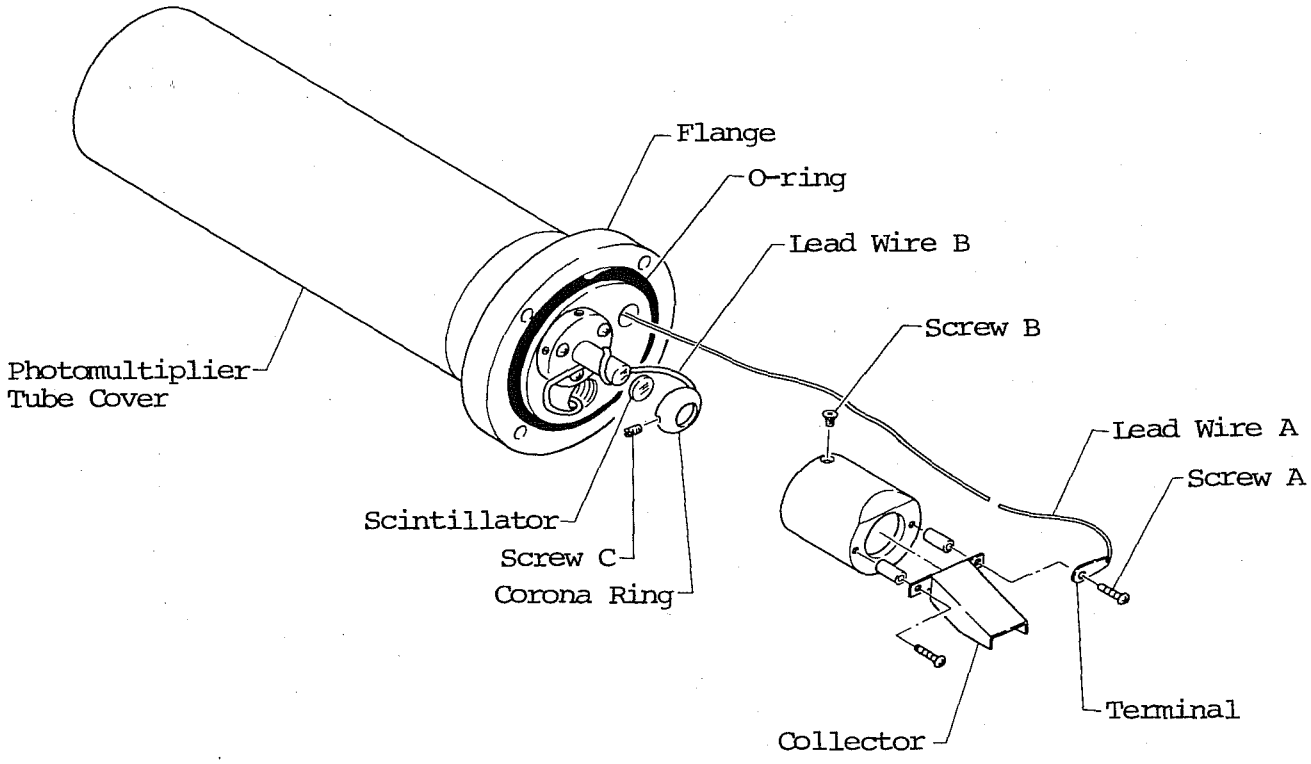


Fig. 6-18 Scintillator Removal

3. Loosen screw A and remove lead wire A. Then, remove collector by pulling it after loosening screw B (refer to Fig. 6-18 also for the following steps).
4. Using a watchmaker's screwdriver, loosen screws C (2 pcs.) that secure the corona ring and remove the corona ring and scintillator from light pipe.
5. If the lead face of light pipe is dirty, clean it.

   Note: Light pipe is quite vulnerable to the solvent. So, to remove the dirt, wipe it off lightly with gauze slightly dipped in alcohol, but do not use any other type of solvent.

6. Attach a new scintillator to the lead end of light pipe with its treated surface outside, using full care not to damage the surface of the scintillator.

   Note: Be careful not to damage the scintillator or light pipe and not to allow dust to stick onto them.

   Especially, do not absolutely touch the surface of scintillator.

7. Put the corona ring on them and secure them with screw C (2 pcs.)
8. Insert the collector to the original position.
9. Mount the detector unit in its original position at the specimen chamber and secure them with Allen screws (4 pcs.).
10. Start the microscope.

    Note: Fig. 6-18 differs somewhat in shape but replacement is the same.

6.8 Lubrication of RP VENT Valve

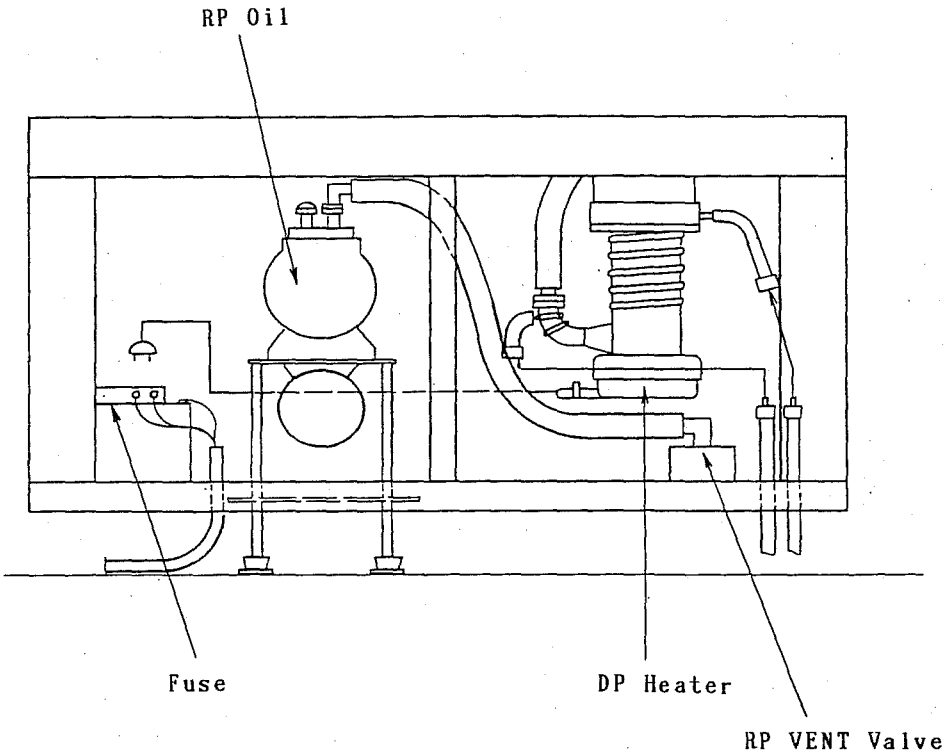


Fig. 6-19 Vent Valve Removal

Apply grease to the vent valve with the following procedures according to the frequency of use of the microscope. (Once a year if it is used everyday.)

1. Turn the [POWER] key switch to [OFF] to stop the microscope and turn off the switch on distribution board. Then, make sure that the oil diffusion pump(DP) is cooled down.
2. Disconnect the vacuum rubber hose and solenoid valve wire from the vent valve.
3. Remove the vent valve from the console.

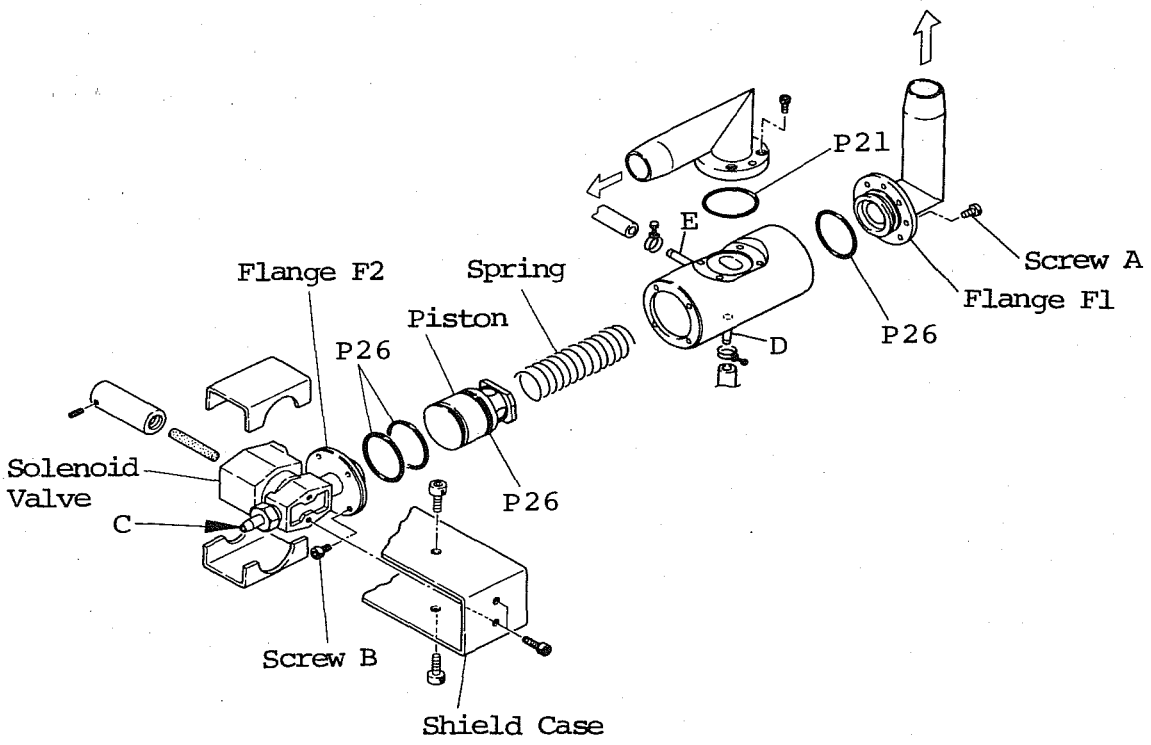


Fig. 6-20 Vent Valve Disassembly

4. Check with wire (below 0.3 mm dia.) that nozzle holes (0.3 mm dia.) at C, D and E are not blocked.
5. Remove screw A and then flange Fl. Take out the inside spring, too.
6. Remove the shield case for the solenoid valve.
7. Remove screw B and then flange F2.
8. Take out the piston positioned inside the vent valve and clean up the vent valve and piston.
9. Apply vacuum grease (Apiezone L or its equivalent) to the inner wall of vent valve and to the O-ring of the piston.
10. Secure the flange F2 with screw B and mount the shield case (refer to Fig. 6-20).

11. Install the piston in the same direction as before disassembly and again apply vacuum grease (Apiezone L or its equivalent) to the inner wall of the vent valve.
12. Install the spring and secure the flange F1 with screw A (refer to Fig. 6-20).
13. Install the vent valve onto the console and reconnect the vacuum rubber hose and solenoid valve wire.
14. Start the microscope.
    Startup: Feed water and turn the [POWER] key switch to [START]⟶[ON].

6.9 Replacement of Oil Diffusion Pump (DP) Heater

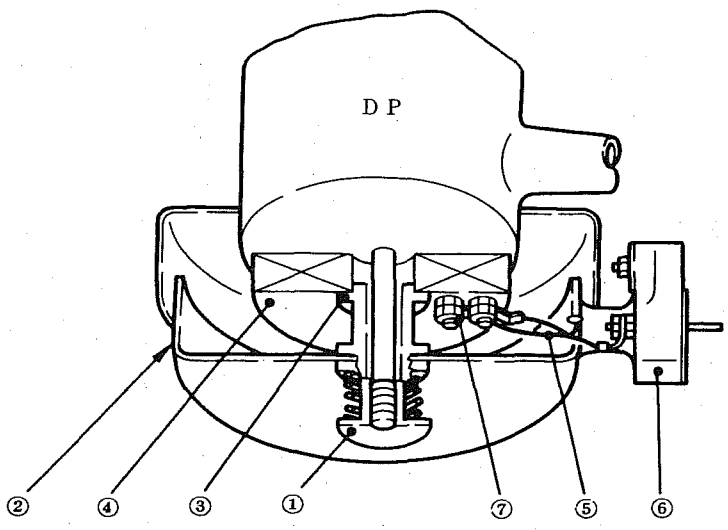


Fig. 6-21 DP Heater

1. Stop the microscope by turning the [POWER] key switch to [OFF] and turn off the switch on the distribution board.
2. Loosen the screws (4 pcs.) at the rear of the column console and remove the rear panel.
3. Remove the oil diffusion pump (DP) heater by loosening the nut (1), after the heater is cooled down sufficiently.
4. Remove the heater assembly from the oil diffusion pump (DP), with metal fixture (3), heater (4), lead wire (5) and plug socket (6) mounted to the lower cover (2).
5. Remove the heater (4) from lower cover (2).
6. Loosen nut (7), disconnect lead wire (5) and take out the heater (4).
7. Mount the new heater.
8. Then, reassemble the oil diffusion pump (DP) in the reverse order of disassembly procedure.
9. Start the microscope.
   Startup: Feed water and turn the [POWER] key switch to [START] ⟶ [ON].

6.10 Refilling of Oil in Oil Rotary Pump (RP)

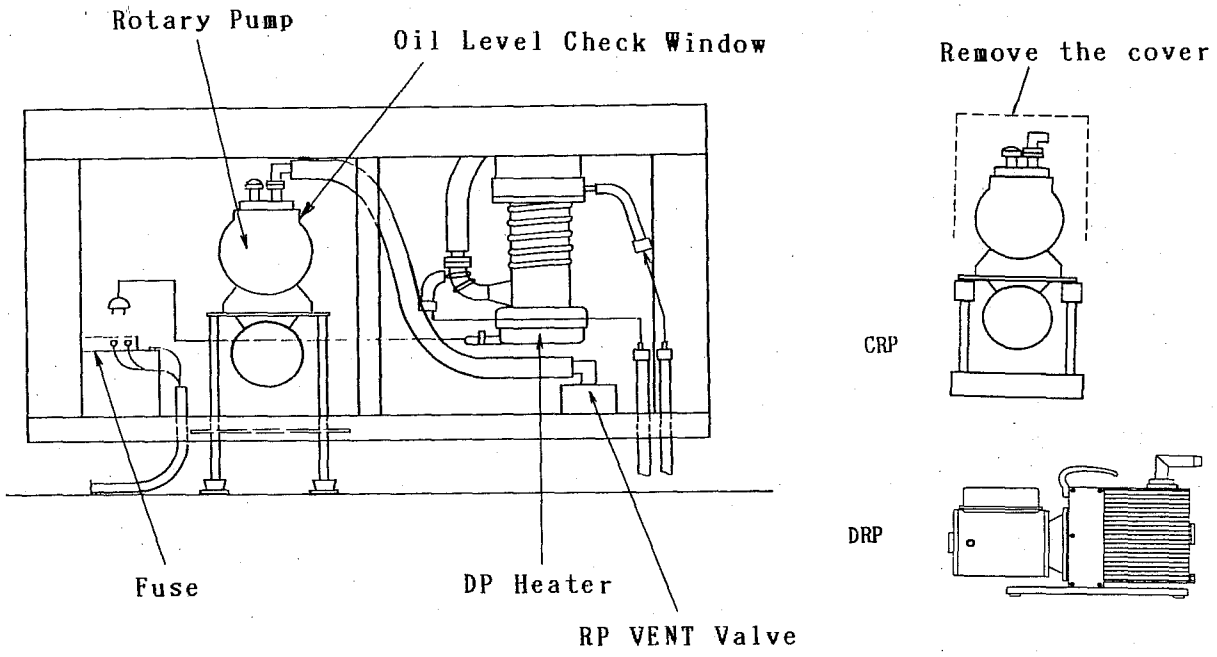


Fig. 6-22 Oil Rotary Pump (RP)

Oil is consumed after long-period use.
Check up the oil level in the oil level check window and add oil if the oil level goes down below the • mark, using the following procedure:

1. Turn the POWER key switch to OFF to stop the microscope and turn off the switch on the distribution board.
2. Remove the rear panel by loosening the screws (4 pcs.) at the rear side of operation console.
   Remove the RP cover for CRP.
3. Remove the cap or oil filter in the upper section of the pump by turning it counterclockwise.

4. Add oil (Neovac MR-200) up to the ● mark.
   Note: The RP oil Neovac MR-200 can be purchased from JEOL Ltd.
5. Reassemble the pump in the reverse order of the disassembly procedure and start the microscope.
   Startup: Feed water and turn the [POWER] key switch to [START] ⟶ [ON].

CRP: Oil Rotary Pump for Clean Room

DRP: Direct-drive Oil Rotary Pump

6.11 Fuse Replacement

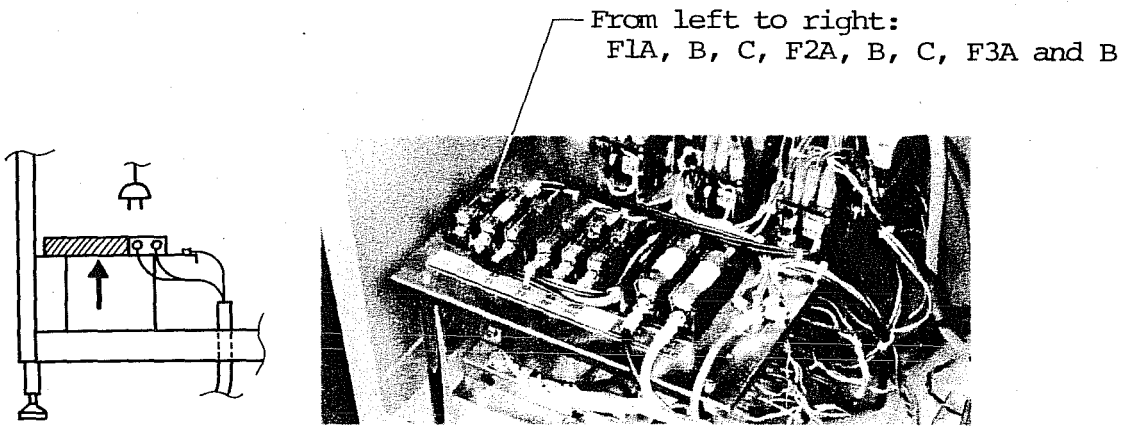


Fig. 6-23 Fuse Holder

Fuse No.	The Circuit To Use Fuse	Standard (JIS)
F1A	±15V power supply	In 3A glass tube (MF03NM-3A)
F1B	Service plug socket	In 3A glass tube (MF03NM-3A)
F1C	T1 transformer	In 8A glass tube (MF03NM-8A)
F2A	T2 transformer	In 3A glass tube (MF03NM-3A)
F2B	Oil diffusion pump	In 8A glass tube (MF03NM-8A)
F2C	Vacuum system	In 20A glass tube (MF03NM-20A)
F3A	Power input	30A cylinder type (CF2-30A)
F3B	Power input	30A cylinder type (CF2-30A)

Table 6-1 Standards (JIS) for Fuses

1. Turn the [POWER] key switch to [OFF] to stop the microscope and turn off the switch on distribution board.
2. Remove the rear panel by loosening the screws (4 pcs.) at the rear side of the operation console.
3. Check the fuse holder and put in a fuse of the same rating as the blown fuse.
4. Start the microscope.

   Startup: Feed water and turn the [POWER] key switch to [START] ⟶ [ON].

Note: Of the supplied fuses, fuses 2A (small) and 1A (small) are for service engineer use.

CHAPTER 7 TROUBLESHOOTING PROCEDURE

CONTENTS

7.1 Trouble Checkup 7- 2

7.2 Trouble at Startup and Vacuum System 7- 3

7.3 Trouble with Image Quality 7- 6

7.4 Examples of Trouble 7-11

APPENDICES

List of Accessories ..... A- 1

Standard Accessories and Tools I ..... A- 3

CHAPTER 7 TROUBLESHOOTING PROCEDURE

7.1 Trouble checkup

If any trouble occurs, check the microscope in accordance with the flow-charts below. If the cause of the trouble cannot be traced, contact your nearest JEOL Service Center for assistance. In this case, give such data as CHECKER meter readings at the respective check points and installation room conditions (room temperature, water temperature, floor vibration, etc.) to the Service Center.

A (Startup and vacuum troubles)

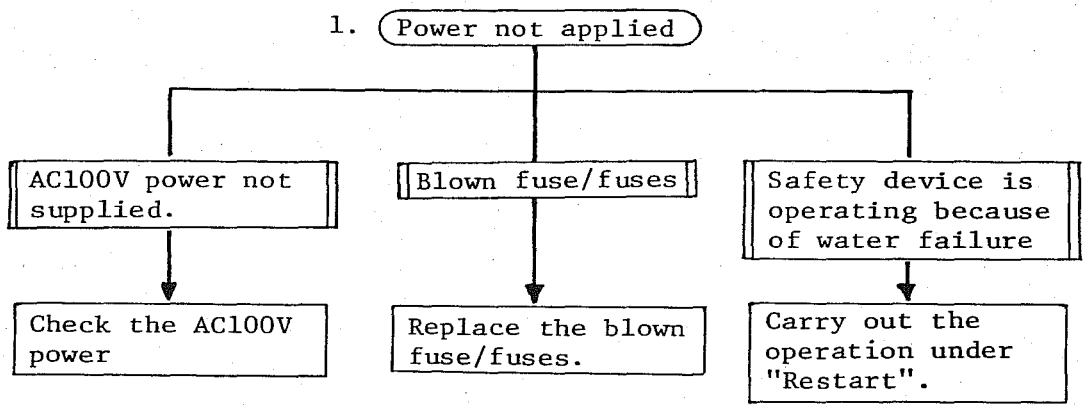
1. Power not applied (p. 7-2)
2. The column not evacuated (p. 7-3)
3. Increased pumping time (p. 7-4)

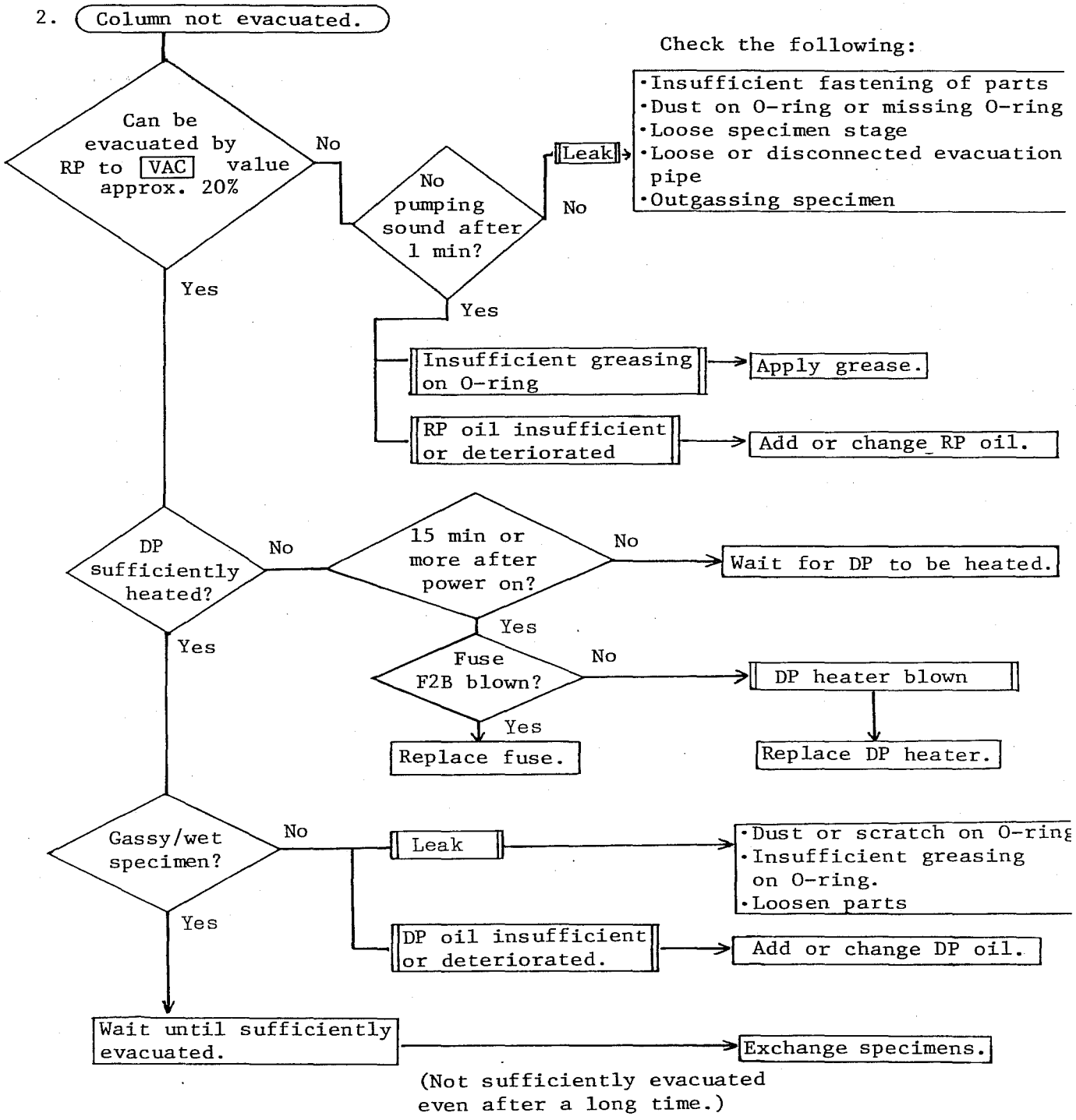
B (Image troubles)

1. No image is displayed (p. 7-5)
2. Abnormal load current (p. 7-6)
   "Load current" means valve on [L.C] of CHECKER.
3. Dull images (p. 7-7)
4. Poor quality images and abnormal images (p. 7-8)
   - . Brightness
   - . Contrast
   - . Image quality (soft/grainy)
   - . Noise
5. Distorted images (p. 7-9)
   - . Distortion
   - . Waviness

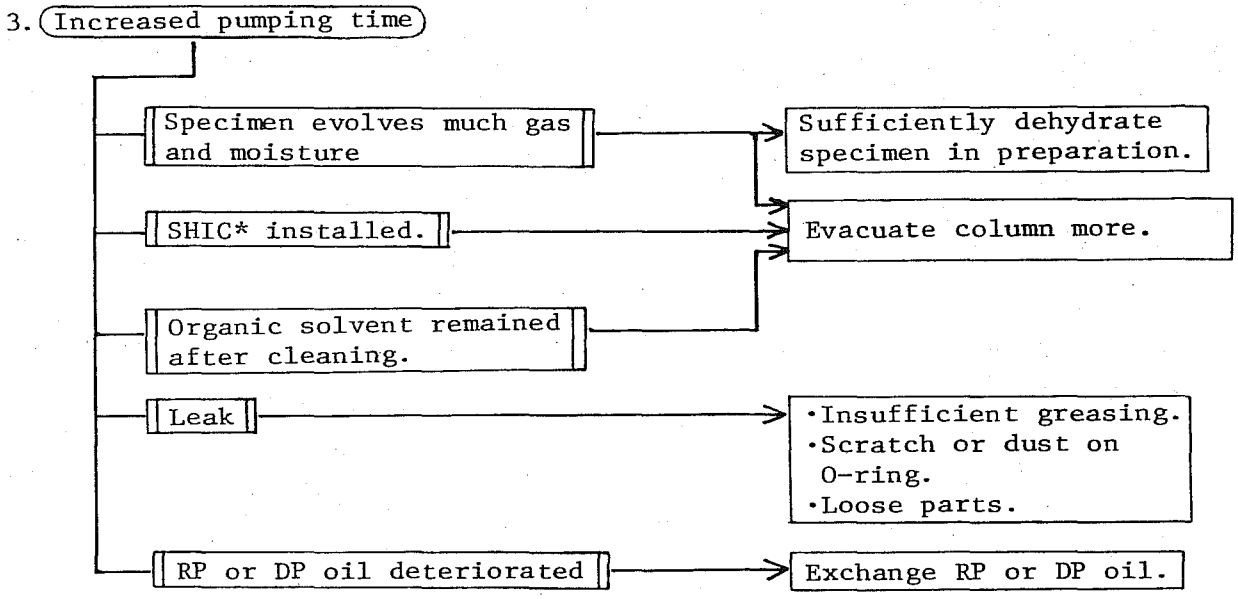
   * Reference: A Guide to Scanning Microscope Observation (by JEOL).

7.2 Trouble at Startup and Vacuum System


1. Power not applied
AC100V power not supplied.
Blown fuse/fuses
Safety device is operating because of water failure
Check the AC100V power
Replace the blown fuse/fuses.
Carry out the operation under "Restart".

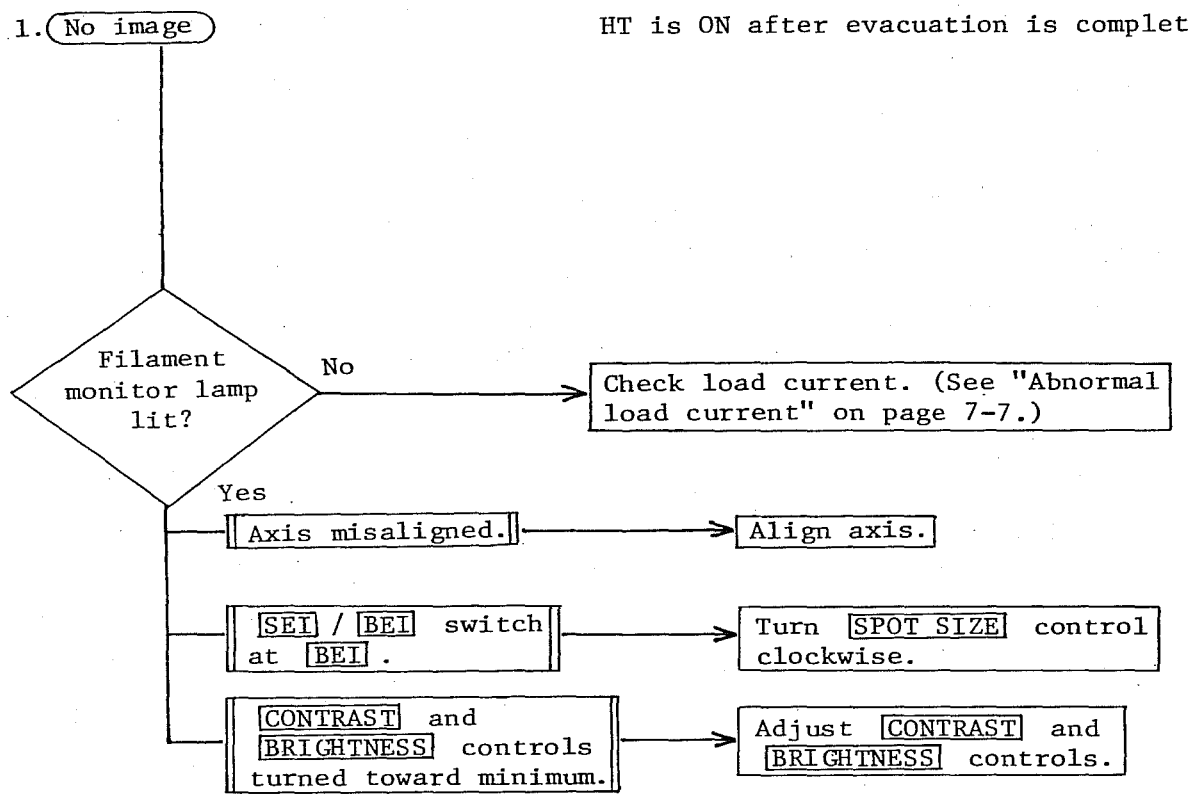


RP: Oil rotary pump
DP: Oil diffusion pump



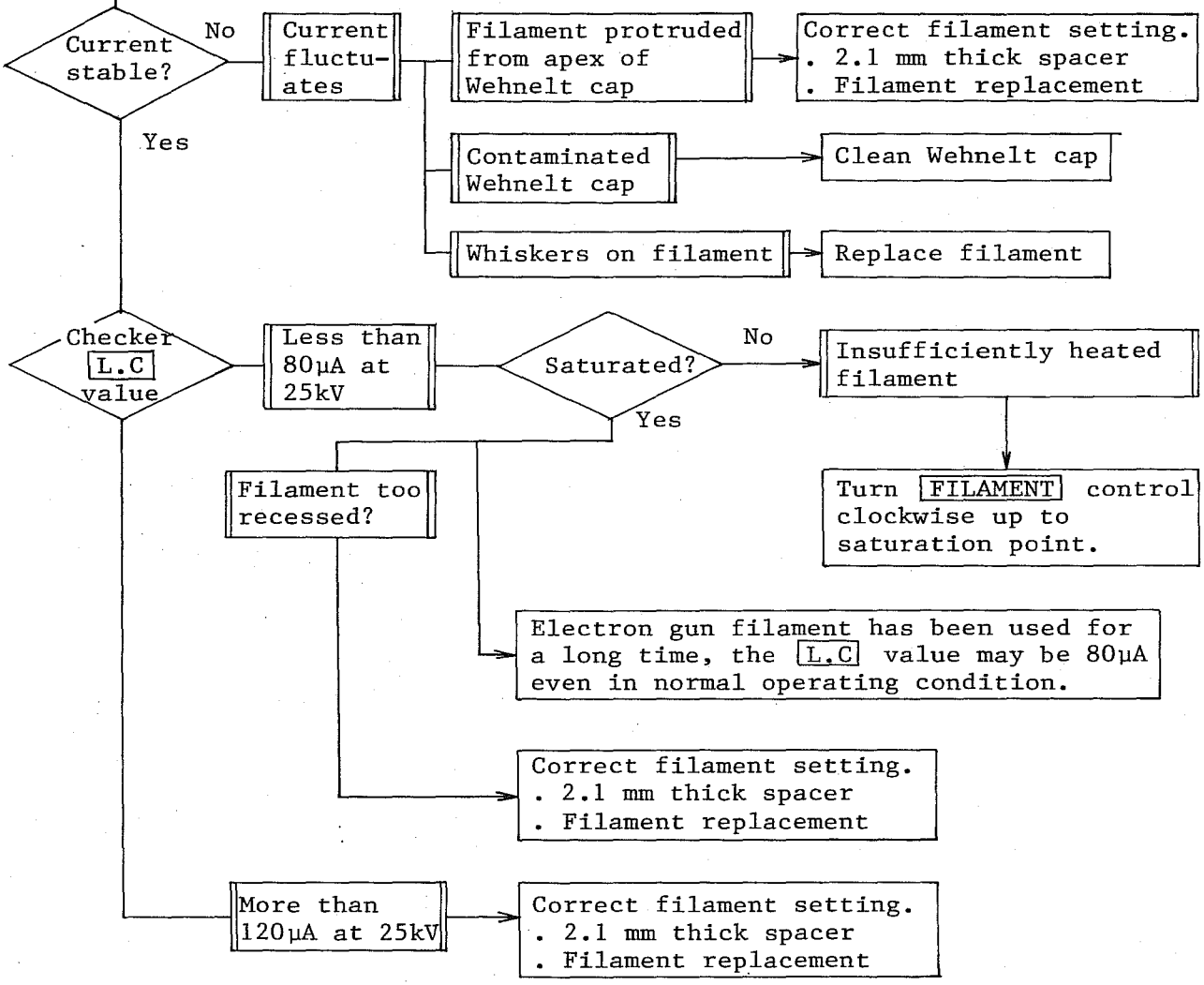
*SHIC: Specimen holder for IC (optional)

7.3 Trouble with Image Quality

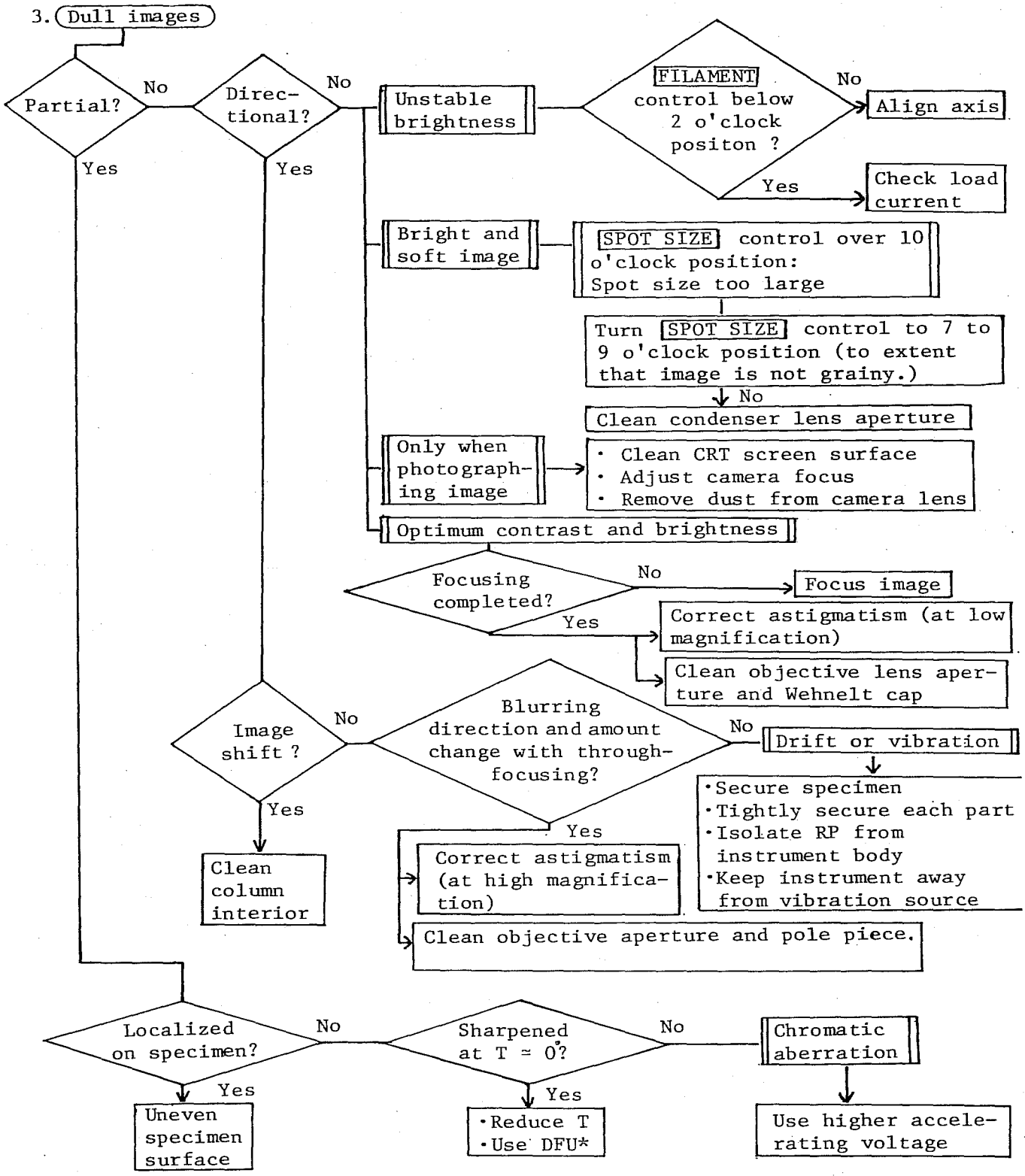

1. No image
HT is ON after evacuation is completed.
Filament monitor lamp lit?
No
Check load current. (See "Abnormal load current" on page 7-7.)
Yes
Axis misaligned.
Align axis.
SEI / BEI switch at BEI .
Turn SPOT SIZE control clockwise.
CONTRAST and BRIGHTNESS controls turned toward minimum.
Adjust CONTRAST and BRIGHTNESS controls.

2. Abnormal load current

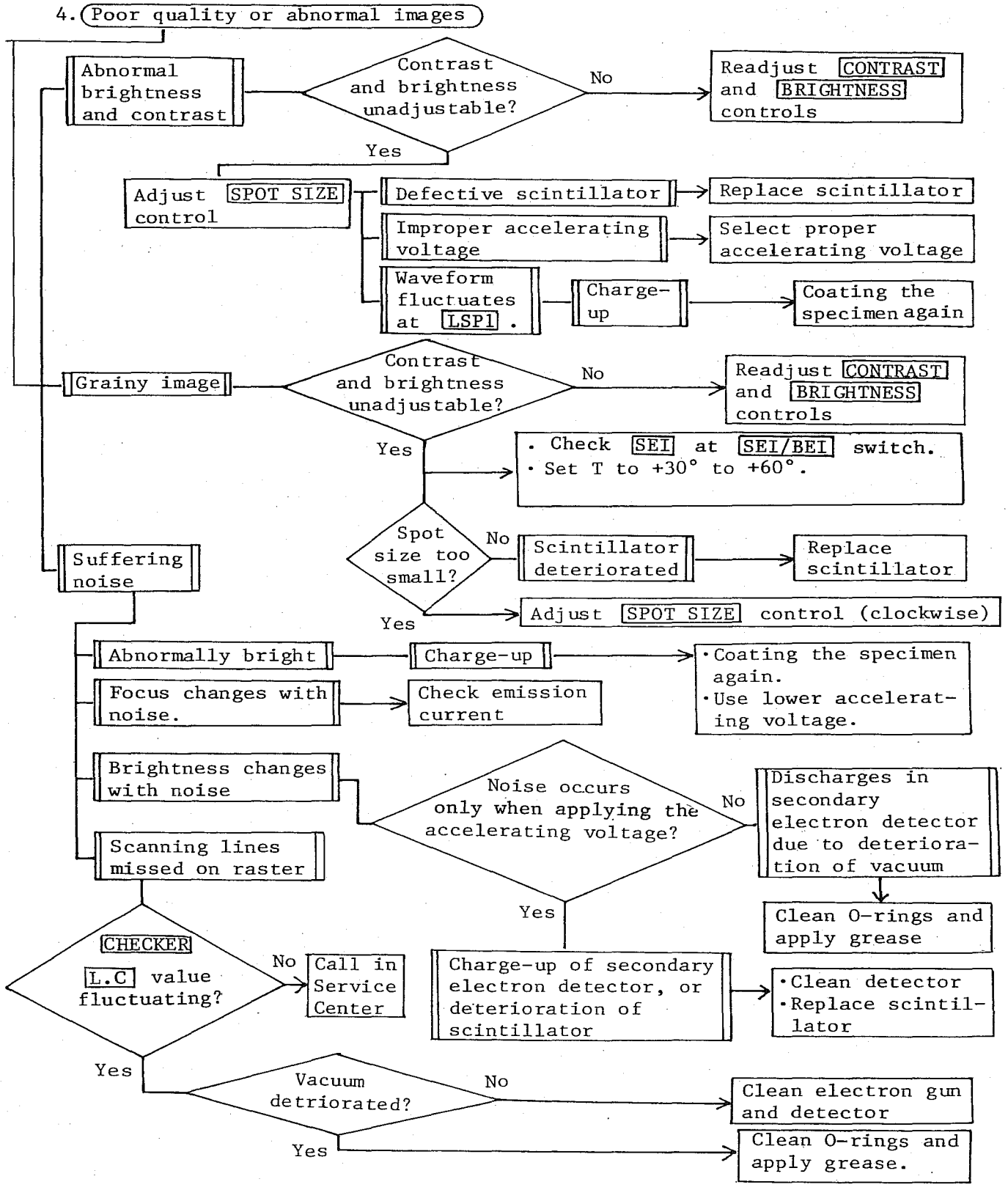
HT is ON after evacuation is completed.



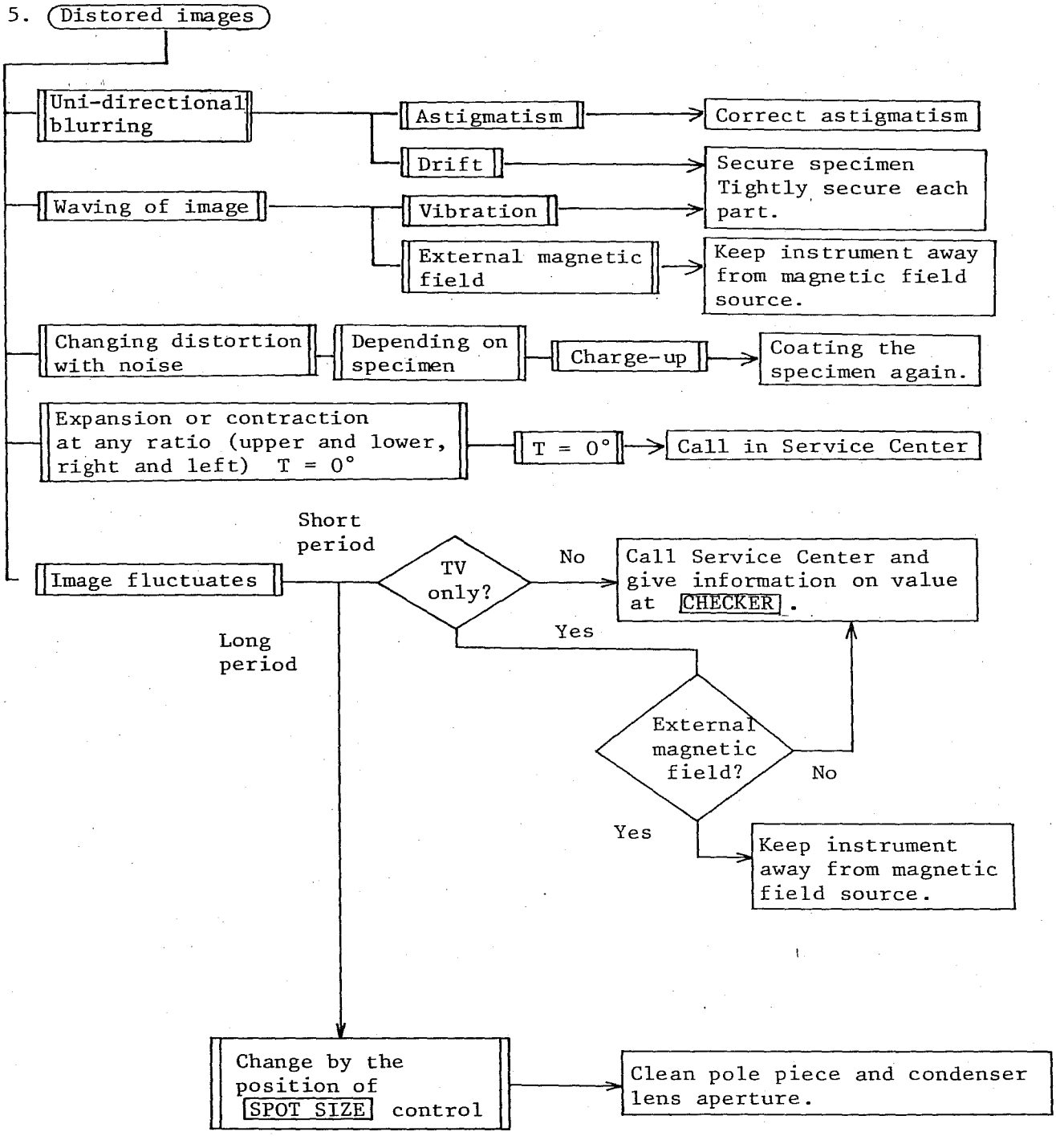
* For measuring the load current, use the CHECK SELECT set at L.C.



* T: Specimen tilt angle
DFU: Dynamic focusing unit (focus correction for tilted specimen; option)


4. Poor quality or abnormal images
Abnormal brightness and contrast
Contrast and brightness unadjustable?
No
Readjust CONTRAST and BRIGHTNESS controls
Yes
Adjust SPOT SIZE control
Defective scintillator
Replace scintillator
Improper accelerating voltage
Select proper accelerating voltage
Waveform fluctuates at LSP1.
Charge-up
Coating the specimen again
Grainy image
Contrast and brightness unadjustable?
No
Readjust CONTRAST and BRIGHTNESS controls
Yes
· Check SEI at SEI/BEI switch.
· Set T to +30° to +60°.
Spot size too small?
No
Scintillator deteriorated
Replace scintillator
Yes
Adjust SPOT SIZE control (clockwise)
Suffering noise
Abnormally bright
Charge-up
·Coating the specimen again.
·Use lower accelerating voltage.
Focus changes with noise.
Check emission current
Brightness changes with noise
Noise occurs only when applying the accelerating voltage?
No
Discharges in secondary electron detector due to deterioration of vacuum
Clean O-rings and apply grease
Yes
Scanning lines missed on raster
CHECKER L.C value fluctuating?
No
Call in Service Center
Charge-up of secondary electron detector, or deterioration of scintillator
·Clean detector
·Replace scintillator
Yes
Vacuum detriorated?
No
Clean electron gun and detector
Yes
Clean O-rings and apply grease.

5. Distored images



7.4 Examples of Trouble

The following symptoms which seem to indicate trouble are mostly settled by maintenance operation. Refer to item 7.
TROUBLESHOOTING PROCEDURE for the symptoms to be trouble other than below.

1. Image does not appear.
   Checkup item : (1) Evacuation sequence [HT READY] on LCD lights up.
   (2) [HT] switch ON.
   (3) Monitor lamp does not light even by turning [FILAMENT] control toward 12 o'clock.
   Major cause : Burnt-out filament.
   Solution : Replace the filament with a new one.

2. Image cannot be distinct.
   Checkup item : Make sure at 25kV, WD 20/10mm by mounting standard accessory specimen (ZnO).
   (1) Astigmatism is corrected and focus is properly adjusted.
   (2) Electron gun is aligned.
   (3) [SEI] / [BEI] is set to [SEI].
   (4) [SPOT SIZE] control is at counterclockwise direction from 12 o'clock. (without roughing the image)
   (5) Not related to the position of specimen.
   Note: As accelerating voltage becomes lower and working distance longer, resolution deteriorates, making it more difficult to obtain sharp images.
   Major cause : Resolution deteriorated by the dirt inside the column.
   Solution : Clean up the objective lens aperture holder, replace the objective lens aperture, clean up pole pieces and replace the condenser lens aperture.

3. Astigmatism increased.

Checkup item : (1) Reset STIGMATOR. (Continue pressing the [STIG] key until the buzzer sounds for about two seconds.)
(2) No correction can be made with the STIGMATOR [X] and [Y] controls.

Major cause : Resolution deteriorated by the dirt inside the column.

Solution : Clean up the objective lens aperture holder, replace the objective lens aperture, clean up pole pieces and replace the condenser lens aperture.

4. Electron probe is not stable (including jump of probe).

Checkup item : (1) Checker [L.C] value is not stable.
(2) Probe jumps even when changing specimen.

Major cause : (1) Underdischarge if whiskers are recognized at the lead end of filament and wehnelt cap.
(2) Charge-up by the dirt inside the column.

Solution : (1) Replace the filament and clean up Wehnelt cap.
(2) Clean up pole pieces and replace the condenser lens. Replace the objective lens aperture as well if necessary.

List of Accessories

* Specimen Holders		
Specimen holder for 10 mmø	1	
Specimen holder for WD 10 mm	1	
Specimen stubs (10 mm dia. × 5 mmh)	2	
Specimen stubs (10 mm dia. × 10 mmh)	2	
* Standard Accessories and Tools		
Specimen stubs (10 mm dia. × 5 mmh)	20	
Specimen stubs (10 mm dia. × 10 mmh)	20	
Conductive paint	1	
Vacuum grease	1	
Fine grain metal polish	1	
Filament spacer (2.0 mm and 2.2 mm thick)	each 1	
Base plate adjusting tool	1	
Screwdrivers (Philips - headed; 3 pcs.)	1	set
Screwdriver (watchmaker's; 6 sizes)	1	set
Allen key wrench (6 sizes)	1	set
Tweezers	1	
Pole piece removing tool	1	
Pole piece assembling tool	1	
Wehnelt cap removing tool	1	
Handblower	1	
Loupe (15×)	1	
Wrench (watchmaker's)	1	
Objective lens aperture	1	set
Removing tool for objective lens aperture	1	
Electron gun filaments (6 pcs./box)	1	
Standard sample	1	

Fuses:	30A	2	
	20A	1	
	8A	2	
	3A (large and small)	each 2	
	2A (small)	2	
	1A (small)	1	
Lamp		1	

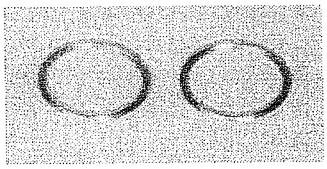
* Parts for Installation and Transportation

Power cable	1	
Water hose (10 m)	1	
Water tap	2	
Plug	2	
Water clamp	4	
Exhaust port plug for RP	1	
Packing (installed in the RP exhaust port)	1	
Vacuum hose clamp	2	
Transporting fixture	1	set
Screws (3 mm dia. and 4 mm dia.)	each 1	set
Rubber-vibration insulators for RP	4	
Legs for RP	4	

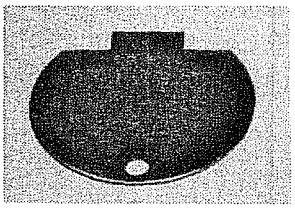
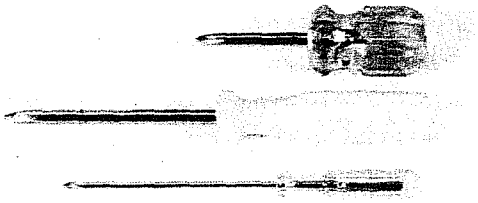
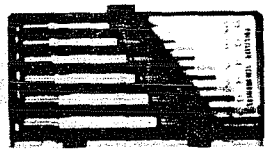
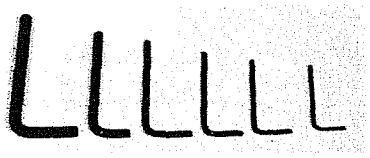
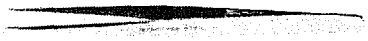
* Others

Instruction manual	1	
Container	1	

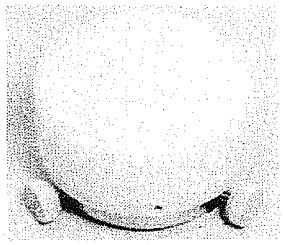
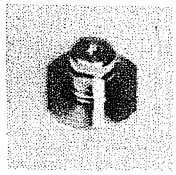
* STANDARD ACCESSORIES & TOOLS I

Name	Appearance	Quantity
Specimen stubs (10 mm dia. × 5 mmh)		20
Specimen stubs (10 mm dia. × 10 mmh)		20
Conductive paint		1
Vacuum grease		1
Fine grain metal polish		1
Filament spacers (2.0 mm 2 mark lines 2.2 mm 4 mark lines)		each 1

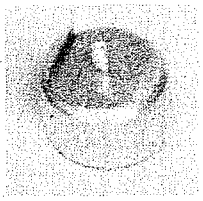
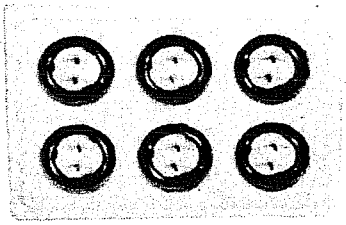
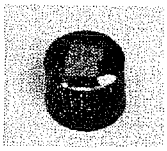
* STANDARD ACCESSORIES & TOOLS II

Name	Appearance	Quantity
Base plate adjusting tool		1
Screwdriver, Philips-headed		1 set
Screwdriver, watchmaker's (6 sizes)		1 set
Allen key wrench (6 sizes)		1 set
Tweezers		1
Pole piece removing tool		1

* STANDARD ACCESSORIES & TOOLS III

Name	Appearance	Quantity
Pole piece assembling tool		1
Wehnelt cap removing tool		1
Handblower		1
Loupe (15×)		1
Wrench, watchmaker's		1
Objective lens aperture		1 set

* STANDARD ACCESSORIES & TOOLS IV

Name	Appearance	Quantity
Removing tool for objective lens aperture		1
Electron gun filaments (6 pcs./box)		1
Standard sample		1
Fuses		30A 2 20A 1 8A 2 3A(large, small) each 2 2A(small) 2 1A(small) 1
Lamp		1